FOOD INDUSTRIES

manufacturing and processing

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Cold Facts

THE AURA of the spectacular that surrounds recent progress in freezing foodstuffs may easily become its most dangerous enemy. We can well afford to be enthusiastic about this progress, for it has blazed a trail to the very center of the problem of preservation and distribution of foods. No one knows how far it may lead us. Yet it is because of these very potentialities that the danger of over-enthusiasm is so desperately vital.

¶ A MISTAKEN DEDUCTION, an error in judgment, or a premature decision would be bad enough were it to retard the development of a single small industry; but in a matter of profound significance to practically every division of the one industry that control's man's very existence, it would approach the borders of calamity. Those at the forefront of the industry—those, at least, who will remain at the forefront—know this well. They are convinced of it not only because they, above all others, have had to deal with facts but because they realize how few facts are known.

¶ THIS ISSUE OF FOOD INDUSTRIES contains ample evidence of the radical differences of opinion as to various phenomena connected with the freezing of animal and vegetable tissue that exist today. Indeed, there are even a number of experimental conclusions that, on the surface, defy reconciliation. In view of the innumerable variations in primary conditions, uniformity of actual operating practice is neither probable nor desirable. Agreement as to the basic fundamentals upon which the industry rests, however, is bound to come; and the sooner it comes the better. It can come, of course, in only one way: by securing more cold, honest-to-goodness facts. To those who are searching for such facts, rather than to those who are making a sporadic and hurried entrance into the manufacture of frozen products merely for the pride of being up-to-date, the industry must look for leadership.

¶ WE NEED MORE FACTS concerning the importance of the size of ice crystals, and the importance of other physical and chemical changes. We need more facts as to the essential difference between slow and rapid freezing, and as to the value of chemical pre-treatment; more facts correlating the most desirable rate of freezing a single cell without deterioration with the most economic rate of freezing such a cell in the center of a piece of meat or a can of peas; more facts concerning the rate of freezing as determined by cell structure, heat conduction, salt concentration, colloidal characteristics, bacterial action, and economics for every individual product that may possibly be frozen; and more facts concerning the temperature necessary to secure this rate. We need all these facts, not merely interpreted to reconcile theories, but applied in actual practice to insure the production of wholesome and attractive frozen foods at a cost that justifies their manufacture.

¶ AFTER ALL, the choice of any particular system of freezing, either from among methods of the present or methods of the future, is not a question for debate. It is a matter of meeting the conditions—facts, if you please—which exist for the particular application. Neither is the future of frozen foods a question for debate; it is a matter that the consumer—recognizing good products as good, and bad products as bad—will settle with unquestionable finality.

Solving the Problems of

RAPID FREEZING

By HARDEN F. TAYLOR
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H. F. TAYLOR

THE first half-century of artificial refrigeration embraced the development of the technique of producing cold—the reduction of the thermodynamic theory to exact science, the selection of suitable liquefiable gases, and the design of refrigeration machines and all their parts. During that period relatively little attention was paid to the technique of applying refrigeration to the preservation of perishable foods, though many applications were made, and numerous academic researches were carried out that laid the foundation of the present era, the period of refined applications of cold. This second era may be said to have begun with the end of the Great War, and was initiated by and for the fisheries industry. If we inquire why this era of applied refrigeration was initiated by the fisheries, an industry that had hitherto contributed little to general technology, we shall find in the answer an important precept for other industries now contemplating the adoption of rapid freezing. Rapid freezing came about in the fisheries to meet certain specific and well-recognized needs and to solve baffling economic problems, which seemingly could be solved in no other way. Without a solution of these problems little hope of prosperity in the fisheries industry appeared possible.

The economic situation was substantially this: Fish are highly irregular in production, they are exceedingly perishable, and the greatest demand exists during the period of lowest production. Overproduction during summer depressed prices below cost, and in winter, when prices could yield a profit, the material on which a profit might have been made was not available. The net effect of these circumstances was a tendency to make the fisheries unprofitable. Another serious obstacle to prosperity was that, in our large continent with warm climates, this exceedingly perishable food deteriorated in transit far too much to be in demand as a delicate food. For these reasons, steady and profitable national distribution could not be accomplished. A preservative was imperatively demanded, one that would permit leveling the peaks of production and consumption from season to season without impairment of quality, and also permit the product to be distributed over the continent in good condition. Refrigeration was this preservative.

The word refrigeration is here used to denote the application of cold all the way from primary production of raw material to its final delivery to the consumer's kitchen, a course comprising many steps. Each step, such as handling prior to freezing, cutting and otherwise preparing for freezing, freezing, packaging, storage, transport, distribution, and retail store refrigeration and display, presents its problems. As all these steps are necessary, it can scarcely be said that one step is more important than another. Experience has taught us that at any of these stages things may go amiss which will impair the quality of the product, even if all other stages are handled in the most nearly perfect manner possible.

Six years' commercial experience with rapid-freezing seems to justify the conclusion that it is merely an improved technique in the particular step of freezing, and not a revolutionary discovery that alone is capable of remaking the perishable-food industry. Indeed, the relative importance of rapid-freezing, in our experience, has greatly declined, and other steps have taken on a new and greater significance. Perhaps it may better be said that the really important stage at any particular time is the one that gives trouble or engages our interest and attention. In this sense, also, rapid-freezing has declined in relative importance, for its problems are chiefly of the past; on the other hand, packaging, distribution, and display now force themselves upon us.

The decision that must now be made by the perishable food industries is not so much whether to undertake rapid-freezing, whether to use this or that system of rapid freezing, or how rapid the freezing must be, or how to cut and package; the question is the much broader one, shall we or shall we not continue the present methods of preparation and distribution; or shall we shift over to a system of freezing, packaging, storage, transportation and distribution, and final sale of perishable foods to the consumer in the frozen condition? It will readily be seen that the answer to this question will not be easy, involving, as it does, complex questions of economics,

trade practices, public acceptance, costs, and disposal of wastes, no less than the purely technical questions concerning the freezing process itself.

In the case of our fisheries industry, we are convinced that circumstances demanded the adoption of this system, and a certain measure of success has seemed to prove that its adoption was sound. That it is successful with the fisheries is proved by the increasing volume of production by the pioneers and by the adoption of freezing systems by many other producing firms in the fisheries.

If conditions in the industries of meats, fruits, berries, and vegetables do, in fact, justify entering upon this new technique of distribution, then there will be interest in the scientific and practical aspects of each stage of the distribution system.

What we know of freezing is not a sudden romantic discovery, nor is it the idea of any one person; it is, like most of our modern scientific achievements, the product of an evolution to which contributions have been made by many scientists, inventors, and business men, in this case, over a period of about 60 years, in many countries. Let us summarize this evolution briefly.

Between 1861 and 1913 at least 18 patents were granted on improvements in the art of freezing fish, several of which covered means of freezing, such as immersion in refrigerated brine or packing in molds to be refrigerated in such a manner as to bring about very rapid freezing. There is no evidence that any of the inventors in this period had any idea that rapidity of freezing was in any way related to quality of the frozen product.

Meanwhile, in the scientific journals a voluminous literature had accumulated, relating to the chemistry, morphology, and microbiology of freezing foods. It was Plank, Ehrenbaum, and Reuter who first published the demonstration, now well known, that when fish are slowly frozen, large crystals of ice are formed in the tissues, and the more rapid the freezing, the smaller are the crystals. These undoubted facts gave rise to the plausible and widely accepted theory that these ice crystals puncture cell membranes, causing the juices of the fish to escape.

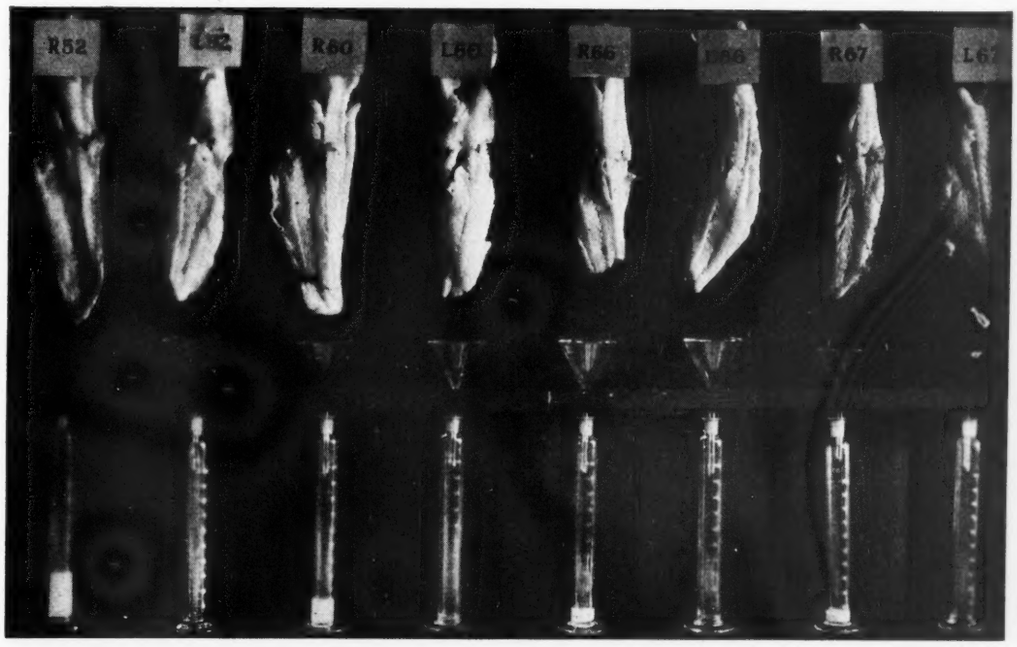
The theory does not seem to explain the observed facts. Meat or fish can be ground and crushed with sand or powdered glass, with thorough laceration of the cells, and then pressed, without yielding any considerable quantity of juice. Juice does not drip from sausage. If such laceration and grinding does not release juice, how can ice crystals do it?

Another of the plausible popular explanations of damage by freezing attributes cell rupture and other physical damage done by freezing to the expansion of water when it freezes to ice. Like the other simple physical explanations, this one is of minor importance. Water occupies its minimum space at 39.2° F., and from this point to ice and 32° it expands 8.1 per cent. Cell membranes, especially of animal tissues, have a decided elasticity. The ratio of surface of a body to volume of contents varies as the $\frac{2}{3}$ power of the diameter; that is, the volume increases as the cube of the diameter, although the area increases as the square. If we double the diameter of a sphere we increase the volume 8 times, the surface 4 times. In very tiny objects, like a tissue cell, the area of cell membrane is very large in proportion to the volume, the expansion of which is very small. A cell as large as a football possibly would rupture the skin in freezing, because of the relatively large volume of contents and small area of surface. Subdivide this several millions of times, squaring and cubing, to the dimensions of cells, and we get tremendous cell-membrane areas in proportion to volume. Even plant cells, of relatively high rigidity, probably are not damaged by expansion.

Research under controlled conditions in our laboratory showed that fillets of haddock when slowly frozen begin to lose juice on thawing and that the quantity of juice lost is progressive with increasing period of storage. Rapidly frozen fillets lose little juice if they are defrosted immediately after freezing, but after a few days' storage they being to develop juiciness, and after a week or two and onward there is little difference in the amount of juice lost by rapidly or slowly frozen fish.

The explanation of these phenomena is found in the nature of the cell and its contents. The crystal puncture theory presupposes that the cell content is a liquid, con-

Fig. 1—Drip test on haddock fillets thawed after 2 days' storage; R52, L52, R60, L60 were slowly frozen; R66, L66, R67, L67 were rapidly frozen. All "L" samples were processed previous to freezing; "R" samples were not.



tained by the cell membrane or skin, and that if this skin is punctured the liquid will run out. The juice that comes from defrosted haddock is, indeed a thin liquid; however, the cytoplasm, or cell content, is not a liquid, but a jelly. Physico-chemical changes occur in the frozen condition that result in the conversion of gelatinous cytoplasm, or part of it, to liquid. This change occurs in both slowly and rapidly frozen fillets.

Reuter[1] also observed these facts. He froze a lot of haddock rapidly and defrosted them at intervals for observation of the consistency of the muscle tissue and the tendency of juice to escape. He found that after 24 hours in the frozen condition, the flesh was still gelatinous or sticky, no juice exuded spontaneously, and but little could be squeezed out. There was, with lapse of time in storage, an increasing development of harshness or fibrousness of the flesh and of volume of juice, to the end that in 149 days' storage the gelatinous condition had entirely disappeared, the flesh was fibrous, and juice ran out as spontaneously as from a sponge.

Attacking this problem, we confirmed Reuter's observations completely, finding losses of juice, in some instances, as great as 24 per cent in rapidly frozen fish. The solution of this problem we found to be a corrective process that maintains the cell content in the gelatinous condition, approximately that of the fresh fish.

Fig. 1 shows four pairs of fillets of haddock, each pair taken from the same fish. The right-hand fillet in each pair (marked "L") was treated by the corrective process; the left-hand fillet in each pair (marked "R") was not treated. The first two pairs (R52, L52, R60, L60) were slowly frozen (about 24 hours). The last two pairs (R66, L66, R67, L67) were rapidly frozen (40 minutes). They were defrosted two days after storage and the juice was collected in graduated cylinders. It will be observed that the untreated fillets, both rapidly and slowly frozen, lost some juice, but that of the treated fillets, neither rapidly nor slowly frozen, lost juice.

Fig. 2 shows fillets of the same series, prepared and kept in the same way as those in Fig. 1, and stored 66 days. The results are similar, but the quantity of juice lost is larger. The order of arrangement is reversed in this photograph. R68, L68, R70, L70 were rapidly frozen; R58, L58, R59, L59 slowly frozen. The "L" samples were treated, and the "R" samples were not.

Fig. 3 shows a series of fillets of hake, all rapidly frozen. The "L" samples were treated; the "R" samples were not; all were stored in the same package 35 days.

Similar results are shown quantitatively in Table I. It will be seen that the juice is not pure water; nitrogen was determined in it by the Kjeldahl method and protein calculated in the usual way.

Table I—Percentage Loss in Weight and Protein for Four Pairs of Haddock Fillets Kept in Storage 52 Days; Defrosting Period, 18 Hours

(Nos. 1a, 2a, 3a, 4a, not treated; Nos. 1b, 2b, 3b, 4b, treated. 1a and 1b are pair from the same fish; 2a and 2b from another fish, etc.)

No.	Wt. after storage	Wt. after defrosting	Wt. of juice	Per cent loss in Wt.	Gr. protein in juice	Per cent loss in protein
1a	324.0	282.0	36.1	12.9	2.77	4.7
2a	310.0	276.0	27.3	10.9	2.43	4.3
3a	450.0	410.0	35.2	8.9	2.81	3.8
4a	360.0	328.0	25.5	8.9	1.93	2.9
1b	325.0	314.0	7.3	3.3	0.55	0.93
2b	303.0	299.0	0.9	1.3	0.05	0.09
3b	461.0	453.0	5.1	1.7	0.31	0.37
4b	363.0	350.0	5.9	3.7	0.31	0.47

In Table II are shown the average results of five such series in storage, respectively, 37, 52, 62, 90, and 101 days. It will be seen that there is with lapse of time an increase of both juice and protein. However, this is not a strictly regular increase in the instance given, for the reason that each figure is the average of only two specimens; individual variation between one fish and an-

[1]Plank, Ehrenbaum, and Reuter: "Die Konservierung von Fischen durch das Gefrierverfahren"; Berlin, 1916; pp. 232-234.

Fig. 2—Drip test on haddock fillets thawed after 66 days' storage. R68, L68, R70, L70 were slowly frozen; R58, L58, R59, L59 were rapidly frozen. The left-hand samples in each pair, marked "L," were treated; the "R" samples were not.

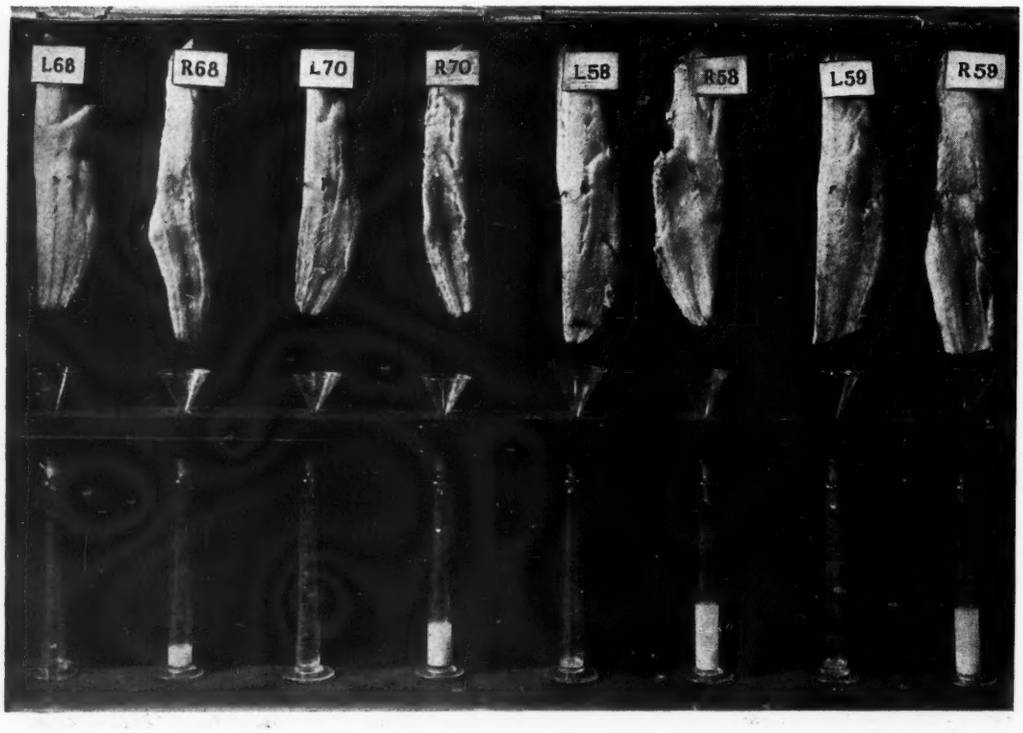


Table II—Average Percentage Loss in Weight

Days in storage.....	37	52	62	90	101
Processed.....	1.3	2.5	4.3	3.19	3.12
Not processed.....	5.7	10.4	13.2	11.52	10.82

Average Percentage Loss in Protein

Days in storage.....	37	52	62	90	101
Processed.....	0.55	0.46	1.12	0.60	0.52
Not processed.....	3.30	3.70	5.84	5.10	4.40

other makes it necessary to obtain averages of large numbers of results to get uniform curves.

These results, confirmed by many other similar experiments, are conclusive. If measures are not taken to retain the original gelatinous condition of the flesh, loss of juice occurs in either rapidly or slowly frozen fish fillets, increasing in amount with the period of storage. If the corrective treatment is applied, little, if any, juice is lost on defrosting either rapidly or slowly frozen fillets. If the treating process is used, it is practicable to produce a good quality frozen fish by slower methods of freezing, though for reasons other than loss of juice, rapid freezing is preferable.

Our data on the loss of juice in meat, and the effect thereon of treatment, are more meager, though some experiments have been made on pork loins. Apparently the tendency to drip is less in pork than in haddock, and this may be true of red meats in general. The results are similar in kind, however, if not in degree. The average loss by drip in 12 rapidly frozen pork loins, untreated, and stored 30 days was 2.6 per cent; in the treated loins, 0.23 per cent. Because the treatment for drip also markedly suppresses dehydration in storage, there was a further difference between the treated and untreated loins due to this factor. Untreated loins lost 2.47 per cent weight in storage and those treated lost, under the same conditions, 0.24 per cent. The net total loss from both drip and dehydration therefore was 5.14 per cent in the untreated, and 0.47 per cent in the treated, pork loins.

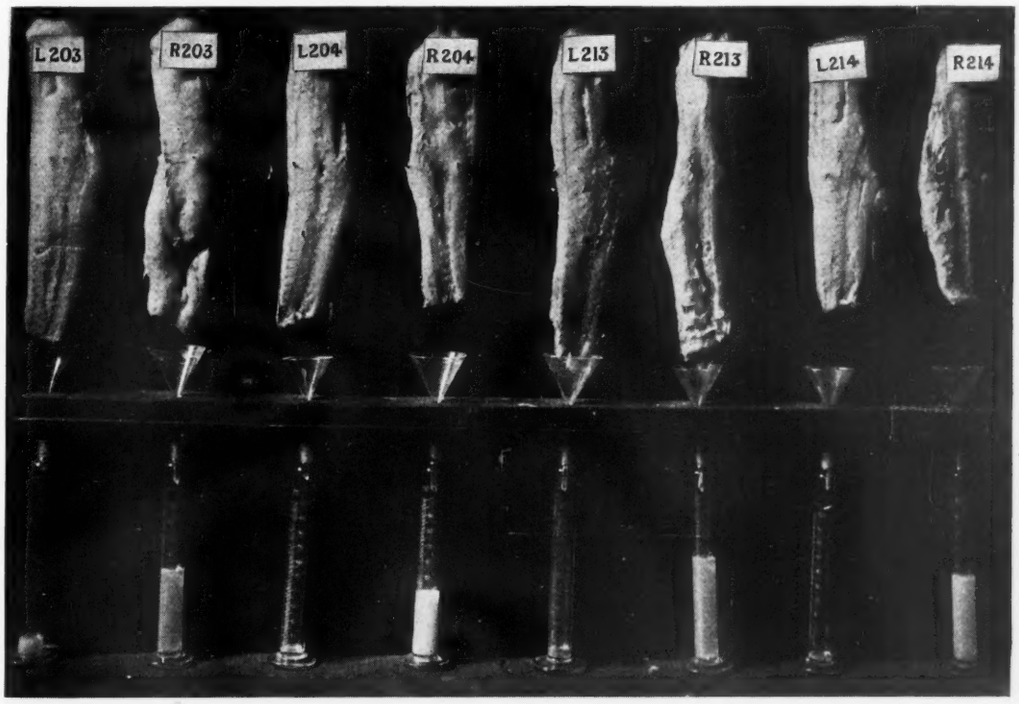
Haddock and other white fish undergo an unfavorable change in color in storage in the frozen condition. Means were found for preventing this change, to the end that it has now been possible for some time to freeze and store haddock fillets without substantial change in color during storage or loss of juice on defrosting. Such experiments as have been made on meats indicate that it is possible to do the same thing with them.

If these findings stand confirmed, the advantages of rapid freezing diminish somewhat in importance. The fact still remains, however, that haddock, treated by the process mentioned, and then rapidly frozen, after a period of storage, are equal to fresh fish for all practical purposes, though not identical with them in every respect. Slowly frozen fish can be prevented from losing juice and, when defrosted, are of excellent quality, though in the frozen condition they are crystalline, translucent, and yellow.

If we freeze pieces of meat at varying degrees of rapidity, marked differences in appearance will be noted in them while they are still frozen. In extremely rapid freezing, as by solid carbon dioxide or liquid air, the meat will be white and opaque, almost chalky. As the speed of freezing is diminished a slight color becomes apparent, the tissue becoming sufficiently translucent to show the color below the immediate surface; at moderate speeds there is still some whitening; but at very slow speeds there is a marked translucence. The difference corresponds to that between fine, white, opaque snow and a block of transparent ice. This phenomenon will assume some importance if foods are to be sold to the consumer in the frozen condition. A very rapidly frozen chicken has a cadaverous appearance like a plaster of paris cast, while one very slowly frozen looks dark because of the visibility of the tissues underlying the surface. There is an optimum of speed that yields a well-preserved product and one that is pleasing in appearance.

Many machines and devices have been patented, proposed, and tried for rapid-freezing. They may be classi-

Fig. 3—Drip test of hake fillets, all rapidly frozen, thawed after 35 days' storage. The left-hand samples in each pair, marked "L," were treated; the "R" samples were not.



fied as direct contact or immersion freezing, and freezing by indirect contact. By direct-contact freezing, the fish or meats are immersed in or sprayed with a cold brine, usually a simple salt solution although other substances have been mixed with the brine, for one purpose or another. Immersion methods are those of Rouart, Rappelye, Henderson, Dahl, Ottesen, Piqué, Newton, Mann, Fyers and Watkins, and Goër de Hervé. Spray methods are those of Kyle, Hirsch, Taylor, and Zarotschenzeff. Direct immersion has never become popular, though for some products it is well adapted. It has not been used widely, mainly because the action of salt on the surface of meat and cut fish produces a dark grayish or brownish color. Inasmuch as we now know how this change of color may be prevented (by means recently discovered), we might profitably reconsider direct brine immersion, especially for the large cuts of meat that are difficult to freeze in any other way. Direct brine contact is the most rapid of all methods of freezing, and has the further advantage of contact over the entire surface. One firm in Germany freezes whole fish by this method and afterward cuts the fish into portions by suitable woodworking machinery. (Ottesen system, at Wesermünde and Cuxhaven.) An objection raised to this procedure is the loss of sawdust when saws are used for cutting large pieces. In the packing houses this sawdust, if free from bone, could, perhaps, be used for sausage.

Most of the methods of freezing that now occupy our attention are based on the principle of indirect contact. In this classification are included such procedures as packing fish or meats in cans and immersing these in brine (Friedrichs, Petersen, Birdseye) or in cells with hollow walls, cold brine being pumped into the spaces in the walls (Hesketh and Marcet, Cooke); in other methods, canvas bags (Hesketh and Marcet), or rubber sheaths (Davis and Skuce), are used. Metal plates cooled from below, either stationary or moving (Cooke) are used, or floating pans (Kolbe). The later method of Birdseye provides refrigerated plane surfaces in the form of metal belts, both refrigerated, between which the packages travel.

Procedures which are distinct from all the above include freezing in cold air blast and by direct or indirect contact with solid carbon dioxide.

A critique of all these known methods obviously is impossible in the scope of a brief article. They are mentioned here mainly to show that much work and study has been devoted to the subject for years. In spite of all the pioneering that has been done in this field, however, it is still one of great possibilities for the engineer and inventor.

Importance of Packaging and Storage Stressed

At the present moment, when the freezing step is monopolizing general attention, those of us who have satisfactory means of freezing are concerned mainly with the problems of storage, transportation, and distribution. Packaging and storage is fully as important as freezing in its possibilities of trouble and its opportunities for improvement. In storage, many changes may occur. Among these are dehydration, evaporation of volatile savory substances, absorption of foreign flavors, changes of color, development of rancidity of fats, and crystallization. Something is known about most of these factors. Although recourse must be had to physical means, such as impervious packaging materials and maintenance of constant temperatures at the most suitable level for most of the protection, we have found that chemical science is able to afford much help, especially in suppressing rancidity and evaporation, and in stabilizing color.

It is found, for example, that the same treatment that is used for preventing drip also has a marked effect in suppressing, though not entirely preventing, dehydration or "freezer burn." Rancidity of fats is closely related to the disappearance of surface moisture. We find that if a surface of frozen fish is allowed to dry, the fat in that surface develops extreme rancidity. Perhaps this is accounted for in part by the dispersion of fat globules in the watery tissues, the fat being protected thereby; upon the disappearance of the water, the fat spreads out by capillary action on the surfaces of the dry tissue residue and is then more exposed to air, as well as to a possible catalytic effect of the tissue substances. But, whatever the explanation, we find that absolute protection from drying helps markedly in holding down rancidity and, as stated above, drying can be suppressed both by packaging materials and by chemical means. Impervious packages also retain volatile flavors and exclude those of foreign origin. The degree of temperature maintained is important. The lower the temperature, the more rancidity is suppressed but the more rapid will be drying, other factors remaining constant. We find 0° to 5° F. satisfactory, though temperatures as low as —5° F. do not seem to be harmful, provided evaporation is prevented.

Carload Shipments Most Economical

It is here assumed that one contemplates national distribution of frozen perishables that reach the consumer frozen. The most practicable and economical method of doing this is to ship in carload lots to cold-storage warehouses from which local and near-by distribution is effected to the retail agencies, rather than to attempt insulation of small unit packages to be sent by express direct from manufacturer to retailer. By the latter process, package cost is high, deliveries are uncertain, transportation costs are excessive, and refrigeration is doubtful, to say the least. If one ships only in solid cars, one may use a relatively cheap unit package and spend the money on permanent insulation of suitable cars, adequately refrigerated for transport to any place on the continent at any time of year. With spot stocks on hand at distribution centers, delivery may be assured and standardized.

The conditions in a car should approximate those of the warehouses at the origin and destination of the goods; that is, the car should itself be a cold-storage warehouse. In the ice-and-salt car the temperature is far from uniform from time to time and from place to place within it. Rising temperatures in the car followed by low temperature in field storage is a severe temperature fluctuation that will not fail to make its impression in the frozen products.

To summarize, experience teaches that national distribution of frozen foods the year round cannot be accomplished satisfactorily by depending on the foods to keep themselves refrigerated by mere insulation. Active refrigeration positively must be provided, and this must be controlled.

The silica gel cars that we have used regularly for two years provide satisfactory means of refrigerated transport. They maintain approximately constant temperatures, controlled by thermostat at any reasonable point desired. As at present used for frozen fish, they are set for 15° F. Other cars have been, or are being, designed to meet these requirements, but the silica gel car

has now been operating for a sufficient length of time to prove its practicability.

The problems of primary storage already considered are, of course, encountered also in the field warehouses, and, in addition, the further problems of obtaining proper conditions of storage where absolute control is not had. In the larger centers conditions usually are good, but many of the smaller towns either have no cold storage at all or else storage is often poorly equipped and not well operated. Foods perfectly frozen and packaged may be ruined in a few days if piled on a warm floor, against outside walls, or in improper or fluctuating temperatures.

It is, of course, possible to make distribution at some distance from distribution centers by truck or short-haul express, but without refrigeration there is meanwhile a marked slackening of temperature, and if the products are then to be placed in electric store refrigerators, we are again confronted by a severe temperature change which is far from beneficial. If retail store refrigerators are not available, the loss of refrigeration in delivery shortens the possible time of holding in retail stores by just so much, increases the risk of loss and makes impossible uniformity of condition of the goods on delivery to customers. For these reasons, suitable field storages are desirable at as many places as possible, and refrigerated trucks will eventually occupy an important place in the scheme of distribution.

To complete the chain of distribution, retail store refrigerators also are essential. They are miniature cold-storage warehouses, and are not exempt from the conditions required of storage, but in addition impose further requirements to provide for frequent opening and for display. Numerous beautiful cabinets have been designed and offered, but there are most serious obstacles to their general adoption at the present time, the principal one of which is expense, not only in capital investment but also in maintenance. It is elemental that from expensive display cabinets a large turnover of goods must be effected. Every factor points unmistakably to a refrigerator common to all frozen products, of whatever source and variety. Numerous refrigerators owned by the different manufacturers of frozen foods are handicapped by limited turnover and occupy too much store space. Not only this, but service and attention is a burden on the distant owner, and the food manufacturer would be responsible for a large capital investment. It seems more logical to look upon the store refrigerator for frozen foods as a part of the store fixtures owned and operated by the store owner. Perhaps it should also be provided with cool space for non-frozen products.

From a broad view of the entire chain of events in the preparation and distribution of frozen foods as the chain now exists, it is evident that the structure of our marketing system is not now set up and ready, in its entirety, for this new scheme. The belief that rapidly frozen foods are ready to be "put over" quickly and all over the country is patently unfounded and futile. Experiment must determine what things can be frozen technically, and economic considerations must determine whether or not they should be frozen at all; suitable freezing methods must be adapted to the things to be frozen, and the facilities must be provided; packagings must be developed that will afford the absolutely necessary protection; a huge fleet of adequately refrigerated cars must come into existence; cold-storage warehouses must be located and maintained at many places where they do not now exist, and first-class operating methods must be assured; refrigerated trucks must be perfected and built in large numbers at a price within economic possibilities; retail stores must be equipped with suitable refrigerated display cabinets; and, finally, the public must be brought to accept the frozen product.

After all these things, a huge job is to be done in giving the prospective frozen-food manufacturer the necessary education and technical background in the new art if blunders are to be avoided which may impede progress disastrously. Perhaps these things will be born of necessity, as good roads were made by the automobile, but before they will be, the basic economic need must exist for frozen foods, as it did for the automobile.

Transferring fish from vessels to the plant of the Atlantic Coast Fisheries Company, Groton, Conn., where much of the research done by Mr. Taylor has been applied to commercial operations

Groton (Conn.) plant of Atlantic Coast Fisheries Company.

How Fillets Are Frozen by the

COOKE METHOD

By LAURENCE V. BURTON
Assistant Editor

THE LARGEST PRODUCER of quick-frozen foods in the United States up to the present time has received no great portion of the publicity. Perhaps this is due to the fact that marketing its products has been less of a problem than the production of a quantity sufficient to supply the demand, for this organization is in that enviable class of manufacturers who could sell more than they are able to produce. As a result, nearly all the creative faculties of the company have been directed at the production end of the business, including the task of procuring an adequate supply of its raw material—fish.

At Groton, Conn., on the east shore of the Thames River, is located the largest plant of the Atlantic Coast Fisheries Company. In it are embodied the highly specialized developments brought into being by Harden F. Taylor, vice-president for scientific research, and translated into large-scale industrial practice by A. H. Cooke. The method of quick-freezing employed by this company is the Cooke system—not the Taylor system, as is frequently and erroneously stated. Although Mr. Taylor has invented several systems of freezing, none of them is in use at this plant.

A Taylor process, it is true, is being used here. This is not a system of freezing, however, but a method of treating fish fillets previous to the freezing operation. It is this process that caused so much discussion at the regional meetings of the Institute of American Meat Packers in February and March, 1930.

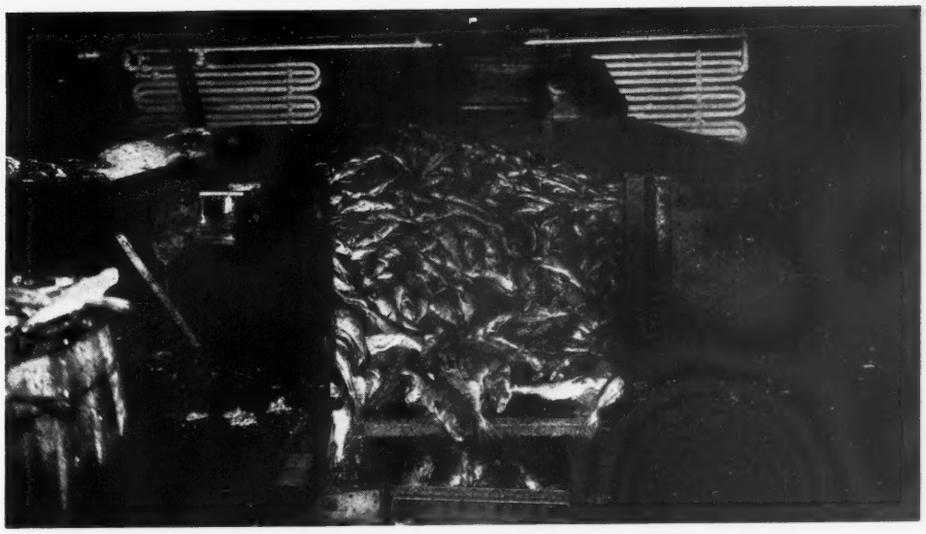
A fleet of 17 large steam trawlers is constantly fishing on Georges Bank and the Grand Banks for the fish from which the frozen fillets of this company are made. Each has a capacity of 250,000 to 300,000 pounds of fish in addition to the ice necessary to refrigerate them. Constant radio communication with the general offices enables the production manager to know what amount of raw material is on board the boats while at sea, and permits him to recall whatever ships are required, producing a more even supply of fish than would be the case were operations not so controlled.

The fish are unloaded at the docks by the usual sling and basket method, and are weighed, re-iced, and hoisted in large boxes on an inclined, overhead monorail system, designed and installed by the Alvey-Ferguson Company. Power is transmitted by an endless-chain arrangement. This system of unloading has a maximum capacity of 55,000 pounds per hour, with 35,000 pounds as an hourly average. The iced fish are stored in large cypress bins on an upper floor of the plant. This storage room is provided with insulated walls and refrigerating coils, which hold the inside temperature at an average of 35° F. The iced fish in bins are the reservoir upon which the factory draws.

Plans are now being prepared to replace this bin system by an apron conveyor from the dock to the storage room, and from the storage room to the work tables where the fish are cleaned and filleted. In the new system, the fish will be kept in large portable boxes holding about 200 pounds. This will eliminate two rehandlings, as well as avoid possible damage to the tissues of the fish inherent in the present method of binning.

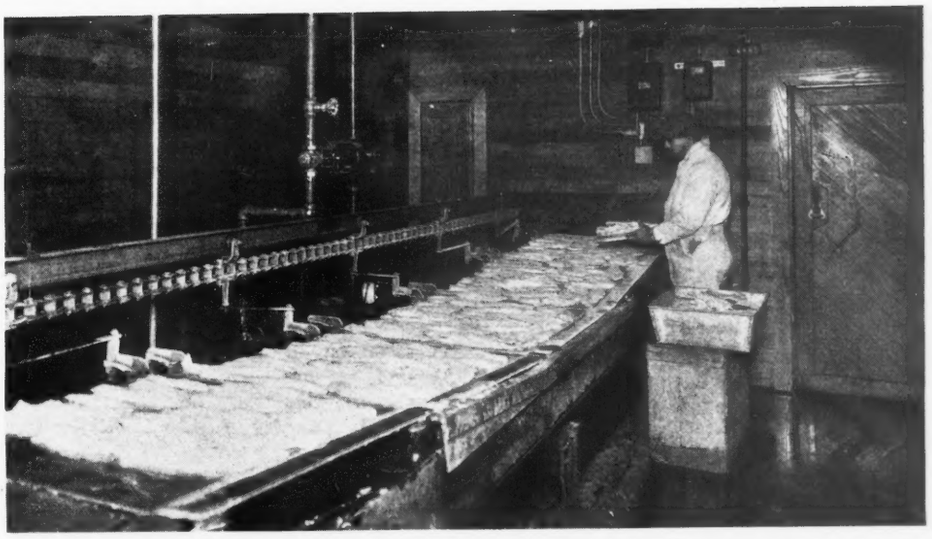
A comparison of the rate of unloading a trawler at 35,000 pounds per hour with the factory capacity of 200,000 pounds per day at once shows the necessity for a reservoir of fish. When the fishing is good, the plant operates 24 hours per day in three 8-hour shifts. The yield of fillets is approximately 39.5 per cent of the weight of gutted fish purchased from the trawling company. The 60.5 per cent waste is salvaged by conversion into fish meal by drying in vacuum evaporators, grinding and putting in stock.

Space does not permit a description of the wage and bonus system in force in the fillet department. Preparation of fish fillets is a hand operation, involving skillful use of the knife. Male operators work in teams of three. One beheads, another de-fins, and the third cuts out the fillets and skins them, if the type of fillet requiring skinning is being prepared. Rates are based both upon fillet recovery and upon the type of operation. Although heretofore considered an impossibility, and meeting with the usual opposition to a bonus system when introduced, the first results with this method of payment have proved satisfactory. Strangely enough,



Cypress bins in a storage room kept at 35° F. hold the iced fish for the short time necessary to even out plant operations.

The finned aluminum plates, covered with a layer of fillets, are moved into the freezing room by the chain drive.



As the plates emerge from the freezing room, passage over brine at 60° loosens the fillets and makes removal easy.

the team that objected loudest to the new system won the highest bonus.

Some of the fillets are prepared with the skins on and are frozen in that condition, after which the skin is easily removed in a planer of the ordinary woodworking variety. This strange application of woodworking machinery is possible with fish frozen by the Cooke system, for the side frozen in contact with the aluminum plate is perfectly flat. An unskinned fillet placed skin side down on the plate can be run through the planer, and the skin removed easily and quickly. Only one precaution is necessary: the planer must have a dull knife; that is, duller than is required for working wood. It has been found that a slight tearing rather than cutting action is desirable in removing the skin of the fish.

Cut fillets are placed in large galvanized-iron pans when they come from the filleting table. These pans are placed in cold-storage rooms, so situated in the plant as to provide the necessary elasticity in the production schedule. As required, pans of these fillets are taken from the cold-storage rooms and enter the much discussed Taylor "pre-treatment" process, in which the fish are mechanically carried through a specific salt solution. Then they are again placed in pans and sent to a lower floor over a gravity roller-conveyor system, installed by the Standard Conveyor Company. The discharge end of the conveyor adjoins the freezing room.

The Cooke freezer is essentially an endless chain of heavy aluminum plates having a number of 5-inch fins on their lower sides. In the freezing room, these ribs or fins dip into calcium chloride brine at —20° F. With the exception of the charge and discharge end of the freezer, by far the greater part of the equipment is housed in a heavily insulated cold-storage room, the average temperature of which is —10° F. After completing the circuit, the aluminum plates containing the fillets rise out of the brine and emerge into the outer room, where they dip into brine thermostatically controlled at 60° F. This operation slightly warms the aluminum plates and loosens the fillets. They are then pulled off the plates and put into galvanized-iron boxes. There are three such freezers at this plant, each with a capacity of 23,000 pounds per day (24 hours). Fillets are frozen in 35 to 40 minutes at —20° Fahrenheit.

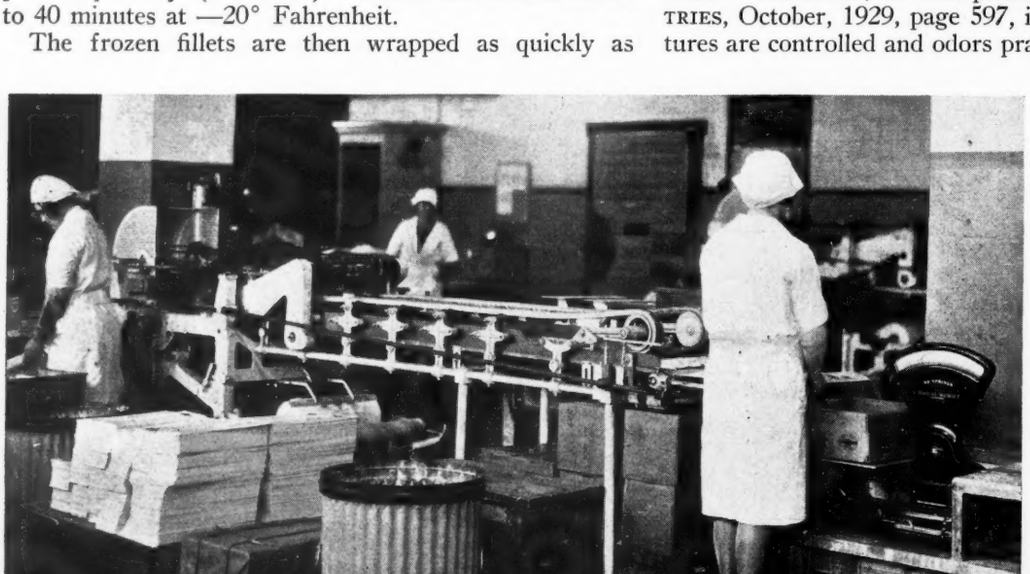
The frozen fillets are then wrapped as quickly as possible and stored at 5° F. Although the freezing itself is almost absurdly simple, the subsequent treatment of the frozen food is of the utmost importance, primarily to prevent the costly shrinkage that results from the evaporation of moisture while the fish is held frozen. For this reason, the frozen fillets must be protected from evaporation by enveloping them in moisture-proof wrappers.

The Atlantic Coast Fisheries Company uses a waxed parchment applied to the fillets by a special wrapping machine made by the American Machine & Foundry Company. The wrapper is heat-sealed. Next it is packed in corrugated paper containers lined with asphaltum-cemented Kraft paper. Tight sealing of this shipping container is most important, and every joint is taped to prevent air transfer through the corners and flaps of the box and consequent entry of heat and loss of moisture.

From the wrapping machine individual fillets are packed for shipment by girls. Use of a specially calibrated Toledo scale holds the net weight in the box at 15 pounds. This first weighing is checked by another girl with a similarly calibrated Toledo scale before final sealing, storage, and shipping. From the packaging department the cases are run into cold-storage rooms chilled to 5° F. and held pending shipment, in order that the temperature throughout the fish and the box be equalized. Railway shipments are made in silica-gel refrigerator cars and local deliveries through the use of silica-gel refrigerator trucks.

The Cooke system of freezing was designed with a view to reducing cost as much as possible by taking advantage of direct heat transfer at moderate temperatures through a good conducting metal surface without intervening wrapping materials but with thin portions to be frozen. Taking advantage of all these factors, freezing is accomplished at relatively high speed at the moderate temperature of —18 to —20° Fahrenheit.

The plant of the Atlantic Coast Fisheries is of concrete construction, so designed as to be maintained easily in a sanitary condition. Adequate provision has been made for drainage and subsequent treatment of wash water. Moreover, as was pointed out in FOOD INDUSTRIES, October, 1929, page 597, inside working temperatures are controlled and odors practically eliminated.



Products of this plant are automatically wrapped in waxed parchment, heat-sealed, and packed in lined corrugated cartons

PAPERBOARD CONTAINERS

For Frozen Foods

By J. D. MALCOLMSON
Research Laboratories
Robert Gair Company

RAPID DEVELOPMENT in the frozen-food industry has been intimately connected with a parallel development of paperboard containers for packaging these products. This progress in these packages is quite logical because of their two outstanding advantages in this connection: economy and efficiency.

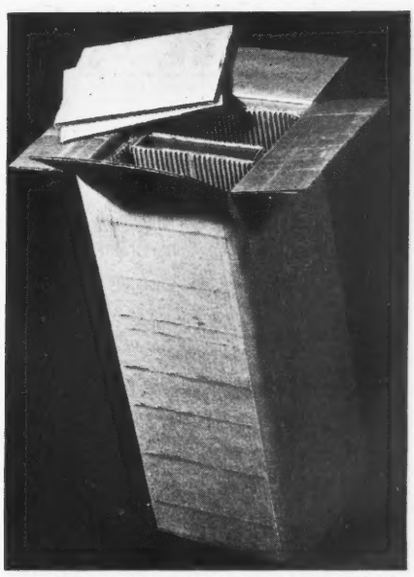
An economical packaging method is an absolute necessity for the proper growth of this great new industry. The paperboard container has demonstrated its economy in the already established industries, promising a particularly bright future in the frozen-food field, because exceptional efficiency is here added to economy.

This happy addition of efficiency is due to the well-known insulating value of all paper products, even in sheet form. This resistance to the transfer of heat can be greatly augmented, however, by various ingenious formations that trap air into small cells. Pockets of "dead" air are, with the exception of vacuum, the most efficient form of insulation known. In folding boxes, the dead air spaces may be obtained by any number of designs which involve double boxes, false walls, projecting tabs between inner and outer boxes, full telescope effects, and the like.

Corrugated board is already an excellent insulator just as it stands, because of the small air pockets inclosed in the corrugated flutes. These pockets are further isolated by creasing and bending the board. Combinations of folding boxes with corrugated linings seem to hold the most promise. Bulk carbon dioxide ice usually is shipped in wooden cases, expensively made and heavily insulated like an ordinary refrigerator. Sometimes these cost as much as $25 for a 10-inch cube size. A corrugated box of the same size, with several liners and pads, can be made for about 15 cents. Granting that the fiber box will not stand as many trips as does the wooden case and that its thermal efficiency is lower, it still is true that the net saving is what counts and that this thought offers an interesting field for some close calculations.

The addition of asphalt not only adds to the thermal efficiency but also conserves the structural strength of the box when handled and stacked in the excessively moist atmosphere of the packing room, the refrigerating warehouse, and railroad car. These conditions are aggravated by the excessive coldness of the product, which causes moisture to condense on the outside of the box. With this thought in mind, keeping the asphalt as near the outside surface of the package as possible would tend to safeguard the stacking strength of the board.

Ice cream preserved with solid CO_2 has so far proved to be the greatest field for the use of paper packages.



TYPICAL PAPERBOARD CONTAINER
with corrugated lining and pads

Pints and quarts are packed in various styles of folding and corrugated boxes, or combinations of both. Bricks in quantities from 1 to 5 gallons are being delivered in multiple-wall corrugated cases. The cream can be held at a satisfactorily low temperature anywhere from 3 to 48 hours (and often longer), depending on the quantity of ice and packing used.

Frozen fish is the other great industry in this category that has definitely adopted the paperboard container. Fillets are wrapped in parchment and then incased in a folding box in amounts varying from 1 to 10 pounds. These, in turn, are shipped out in asphalted corrugated boxes carrying 15 pounds or 30 pounds, net. The insulation is so efficient that the fish is delivered in the frozen state after traveling half way across the continent, and without the use of solid CO_2 or other additional refrigerant.

Other frozen product fields for the paperboard container that have either adopted it or have instituted a scientific study of it include oysters, fresh meats, fresh fruits and vegetables, medicinal products, and similar products. Many of these are already using paper, either in the form of folding boxes or corrugated shipping containers. These developments have worked out so satisfactorily that it is now hoped frozen fruit juices, even, may be so packed.

Other researches now under way on this subject include:

Advantages or disadvantages of ventilation holes in corrugated board.

Nature of heat transfer in paperboard containers—whether by conduction, convection, or radiation—and their relative importance.

Effect of corrugated insulation on the rate of defrosting speed.

Single-wall corrugated boxes with liners as compared with double-wall boxes.

Relation of cold air circulation to dead air insulation, including the proper location of the refrigerant.

These investigatory leads, taken at random from the laboratory's bulky card index, serve to indicate the fact that progressive box makers are keenly aware of the important rôle they are destined to play in the growth of the frozen-food industry.

PACKAGING

Quick-Frozen Foods

By CLARENCE BIRDSEYE
Vice-President, General Seafoods Company, Gloucester, Mass.

THE PLACARD reading "Cold Storage Goods Sold Here" is no longer necessarily a sign of a market where fish of doubtful quality are sold. Two factors of almost equal importance have been responsible for the great improvement in the quality of most of the frozen fish offered for sale. Quick freezing, the first factor and the one receiving great publicity, has made possible the production of frozen fish of high quality. Modern packaging methods and materials, the lesser known factor, permit the storage of the frozen product and make possible the transportation and retailing of the fish months after its capture.

Old-fashioned sharp freezing and cold storage greatly retard bacterial and autolytic decomposition, but permit deleterious changes which soon cause the fish to lose many of the characteristics that usually are recognized as "fresh" qualities. If a frozen fish, without any protection to keep it from drying out, is stored in a very cold room it soon becomes as dry and porous as a piece of bark. A strip of fish, such as a fillet, dries out in even less time. Dipping the very cold fish in water glazes them over with a thin coating of ice, and, by evaporation of water from the glaze instead of from the fish itself, materially retards desiccation. Whole fish may be fairly well protected by frequent glazing, but fillets are much more difficult to keep in good condition by this treatment.

Desiccation of unwrapped fish permits many undesirable changes to take place. The fat of partly desiccated fish oxidizes rapidly and becomes rancid and yellow. Desiccated fish never rehydrates properly and loses much of its flavor. It absorbs odors from contaminated storage rooms, refrigerated freight cars, and dealers' ice boxes.

Storage of the fish at very low temperatures retards oxidation of the fat, but, unfortunately, the lower the storage temperature, the more rapid the desiccation. If a refrigeration room can be solidly packed with fish, air currents are materially lessened and dehydration of the stored fish is greatly reduced. Unfortunately, in the case of whole fish and unpackaged fillets, such complete filling of the cold storage is not possible.

Quickly frozen, unpackaged fish or fillets offer the same difficult storage problems as those outlined above for fish slowly frozen. In fact it is impossible to store unwrapped either slowly or quickly frozen fillets for any length of time and have them remain in good condition, because of the large surface exposed to evaporation and oxidation.

If the frozen fish are to be handled in relatively small lots or marketed at retail, it is necessary that they be packaged in heat-insulated containers; otherwise, it is likely that they will partly or completely thaw out during transportation unless mechanical refrigerated trucks or cars are used. In the case of small shipments, mechanical refrigeration is often a costly procedure. In the case of both large and small shipments of frozen fish, even though not always necessary, the careful heat insulation of the packages always is desirable, for it insures the product reaching its destination in good condition provided that no unusual delay takes place en route.

The fish must be protected in some way by packaging

to prevent loss and changes of flavor during transportation and storage. Fortunately, wrappers which protect against desiccation also prevent, to a considerable extent, the evaporation of volatile substances and the absorption of odors. Similarly, such wrappers aid in preventing bacterial contamination after packaging.

The retail dealer demands that the individual packages themselves be clean, dry and odorless; and if the fillets are to be thawed before sale they must retain their attractive appearance, and require the minimum weighing and wrapping before delivery. The ultimate consumer of the fillets expects the product to be in perfect condition in regard to flavor, juiciness, and color. The fillets must be absolutely clean in the first place, must be sanitarily handled throughout the production and packaging process and in such a manner that they are effectively protected from contamination during transportation and sale. Most housewives also want fillets ready to cook as soon as they are taken from the package.

CLARENCE BIRDSEYE

In addition to all the foregoing packaging requirements, the modern consumer requires that the packaged product possess an attractive appearance. This is especially true if the frozen fish is to be sold at retail, as is the case with most of the haddock fillets now produced. Although this last requirement may seem to the old-fashioned fishmonger to be one of secondary importance, the modern housewife judges the quality of the food she buys chiefly by its appearance, and demands not only that it taste well but also that it look well.

A consideration of all these factors or requirements indicates that the satisfactory packaging of frozen haddock fillets is one of the most difficult problems ever considered by package engineers. Not only does he have to develop a method of packing which will fulfill all the requirements discussed but he must design a package which will require a minimum of wrapping and cartoning material for a given weight of product. If the fish are to be sold at a relatively low price in competition with fresh fish, it is necessary that the individual packages and cartons and all of the wrapping material be inexpensive, preferably rectangular, and packed solidly full. Further, if the fillets are to be packaged before freezing, they must be so packed as so facilitate quick freezing.

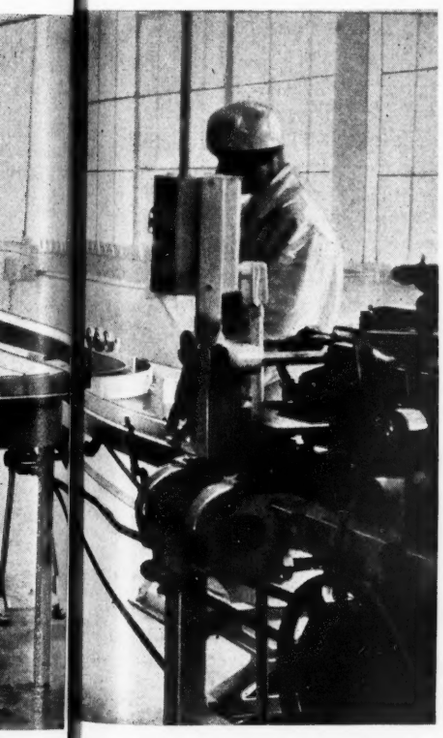
From a consideration of these points, it has seemed to us that this problem can be solved most satisfactorily by packaging the fillets prior to freezing; this is due to the fact that unfrozen flesh products are soft and yielding, and the individual fillets can be made to fit together solidly and completely to fill the carton in which they are packed. If the fillets are frozen previous to being wrapped and packed, they are unyielding and of irregular shape, and cannot be placed compactly in a package.

To illustrate this point, data relative to the volume occupied by 1 pound of fish fillets and other products unfrozen, packaged and then frozen, frozen and then packaged, are given in the following table:

Table I—Space Occupied by Certain Frozen Foods

Product	Volume Occupied By 1 Pound		
	Unfrozen Cubic inches	Packaged and then frozen Cubic inches	Frozen and then packaged Cubic inches
Haddock fillets	26 to 27	29 to 30	54 to 90
Salmon fillets	26 to 27	29 to 30	64 to 70
Codfish steaks	26 to 27	30 to 31	51 to 55
Shelled oysters	27 to 28	29 to 30	56 to 59
Sea scallops	26 to 27	29 to 30	57 to 59
Lamb kidneys	26 to 27	28 to 29	38 to 43
Lamb chops	26 to 28	30 to 31	44 to 48
Sirloin steaks	26 to 28	29 to 30	45 to 47

It should be noted that if haddock fillets are packaged and then frozen, they require a volume less than half that of the product frozen first and then packaged.



Rectangular 1 pound cartons are compactly packed previous to freezing.

The volume occupied by a package containing a given weight of frozen product is important from the standpoint of heat insulation, for, assuming the packages are alike otherwise, the heat transfer into the package is directly proportional to the total area of the surfaces of the package. This means that not only is a much larger package and more wrapping material required to hold a given weight of haddock fillets if the fillets are frozen prior to packaging than is the case when the fillets are packaged and frozen but also that more insulation is required to insulate the fillets equally well. Furthermore, a given weight of compactly packed packages occupies in storage much less volume, and as cold storage is very expensive, the poorly packed package is a more costly one to store.

If a ½-pound fillet is laid out flat and frozen individually, its total area is approximately 83 square inches. Twenty of these fillets, required for a 10-pound package, laid out flat and frozen individually would have a total surface of approximately 1,660 square inches. When packed solidly in a 10-pound carton before being frozen,

the total surface exposed to desiccation and oxidation is only 350 square inches, less than one-quarter of the surface of the individual fillets.

Kinds of Packaging Materials

It is absolutely necessary to wrap the fillets with moisture-vapor-proof wrapping of some kind to prevent desiccation during storage. This wrapping is expensive, especially if moisture-vapor-proof Cellophane is used; for this reason, if for no other, packaging prior to freezing is desirable.

One of the first materials to be used for wrapping fillets was vegetable parchment paper, paraffin coated on both sides. This waterproofed parchment paper is excellent, for it is nearly moisture-vapor-proof and does not disintegrate in water even when boiled in it; however, when frozen it tends to crack.

Glassine paper, paraffined on both sides, makes a satisfactory heat-sealed wrapping for the outside of small cartons, as it is nearly moisture-vapor-proof and is fairly transparent. Unfortunately, it gradually loses strength when wet, and therefore is not suitable for direct contact with moist products.

If the fillets are packaged before freezing, cold-waxed cardboard cartons lined with moisture-proof Cellophane have been found to be very satisfactory. When packing larger packages, the individual fillets may be wrapped in moisture-proof Cellophane, and then packed in cold-waxed cardboard cartons. This wrapping material has the advantages that it is almost completely moisture-vapor-proof, watertight, grease-proof, and in addition is almost completely transparent, but its use is limited by its high price. Ordinary transparent cellulose, such as Cellophane, cannot be used, because it is not moisture-vapor-proof and because the sheets adhere to each other both while the product is frozen and after it has thawed.

Corrugated Fiberboard Shipping Cases Used

The necessity of using inexpensive, non-returnable shipping containers makes impractical the use of the time-honored insulating materials, cork and balsa wood. Corrugated fiberboard containers have been found to possess about as great insulating value as cork board and moreover, are relatively cheap. Corrugated fiberboard made from various materials (chip, jute, straw, or kraft) has been found to possess practically the same insulating value. Experiments performed in our laboratory have indicated that containers of solid fiberboard do not possess quite the heat-insulating value of corrugated fiberboard.

Ordinary corrugated fiberboard shipping containers do not sufficiently insulate the frozen product for shipment in anything other than refrigerated railroad cars or trucks. To give the required thickness of fiberboard for sufficient insulation to permit other means of shipment, corrugated fiberboard pads or liners are placed within an ordinary slotted carton of the proper dimensions. The number of liners required depends upon the size of the package, the shipping conditions (length and temperature of transportation period); under average conditions four liners are enough.

The method of sealing the fiberboard containers is not important from the heat-insulation standpoint. Formerly we used sodium silicate to close the top, and then completely sealed all the joints with tape. Sealing with silicate and one strip of tape, or simply stitching the top and bottom of the container seem to work equally well.

The largest shipping containers practicable should be used, since the larger the container, the smaller the ratio of surface area to weight of contents, and consequently the longer the contents will be protected against thawing. Laboratory experiments have indicated that 4 pounds of frozen haddock fillets packed in a corrugated fiberboard container suitable for this weight will completely thaw out in about 44 hours. Product packed in a container of similar construction holding 12 pounds thawed out in 72 hours, whereas 92 and 144 hours respectively were required in the case of the 24- and 48-pound packages. The container should be as nearly cubical as possible, so as to expose the minimum surface to heat penetration.

It has already been pointed out that the cartons should be packed solidly full of fillets. For the same reasons the shipping containers should be packed solidly full of cartons.

Package Permits Display Without Deterioration

The packaging methods and packages employed in the plant of the General Seafoods Corporation have been developed through a consideration of the points discussed above, and have proved to be satisfactory commercially. The packaging consists of either wrapping the individual fillets in moisture-proof Cellophane and then placing the wrapped fresh fillets in cold-waxed cartons and packing completely full, or, in the case of the 1-pound packages, in packing the cut fresh fillets solidly in cold-waxed cartons lined with moisture-proof Cellophane or, in some cases, waxed vegetable parchment; closing the carton, wrapping it in paraffined glassine paper, and hot-sealing. In either case the top of the carton may be raised and the contents displayed in a showcase or refrigerator cabinet without exposing the frozen fillets to desiccation and oxidation, as they are still covered with the Cellophane. The cartons of fillets are then placed in the Birdseye quick-freezing machine and quickly frozen, and then chilled to —20° F. in a cold room. The cartons of frozen fillets are then packed solidly in large corrugated fiberboard containers fitted with about four corrugated fiberboard liners. The corrugated fiberboard containers are closed with a dextrin adhesive.

The information given in this article has for the most part been derived from sea-food products. Most flesh foods, however, are broadly similar, and the methods which have been suggested for fish fillets are, with proper modification, largely applicable to quick-frozen packaged meats, poultry, and meat products. Vegetable matter, on the other hand, is in many ways unlike animal tissue and quick-freezing does not present the same advantages in the freezing of fruits and vegetables that it has been proved to afford in connection with the distribution of flesh foods. Even with vegetable matter, however, quick-freezing and proper packaging in rectangular paper cartons have many advantages, and are worthy of serious consideration.

The packaging and quick-freezing of perishable food products of various kinds is a recent art and is still, except in the case of a few products, largely experimental. Undoubtedly, there is a tremendous future for products preserved and distributed by means of refrigeration, but this field will be realized only by the expenditure of much time and money. Enthusiasm, unless backed by real knowledge of the problems involved in preparing and marketing any particular product, is likely to do this new industry more harm than good.

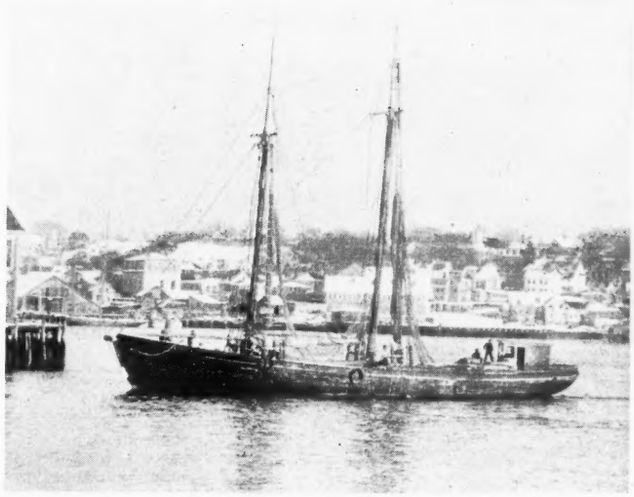


Fig. 1—Modern methods of fish preservation have failed to rob the Gloucester fishing fleet of its picturesque quality.

FREEZING FISH

By the Birdseye System

By E. SCOTT PATTISON
Editorial Staff

THE FINAL WEEK in February was a remarkable one for the New England fishing industry. As boat after boat came to port with an exceptional and unseasonal abundance of fish, the demand slowed, then faltered, and almost came to a halt. The market in Boston was glutted, and the impossibility of distributing the total supply on a profitable basis sent the price down to almost 1 cent a pound.

On a pier in the harbor of Gloucester, Mass., however, there was great activity. Here the demand did not come to a sudden stop. Hour after hour, tens of thousands of pounds of fish were lifted out of the holds of the fishing fleet. On this particular pier, more than 500,000 pounds was landed. But these fish did not add to the distress of an overstocked and unprofitable market, nor did they deteriorate unsold. In the leaner weeks that follow the big catch, the stored products go out day after day to supply a normal, even, and profitable demand for fresh fish of the finest quality. They are shipped out in a waste-free and attractive form, traveling thousands of miles inland without danger of spoilage.

The reason, of course, is freezing. At the plant of the General Seafoods Corporation, a subsidiary of General Foods Corporation, these 500,000 and more pounds of fish were cleaned, filleted, packaged, and quick-frozen in five days. Then they were stored away until the ever-increasing demand absorbed them.

The thorough cleaning that the fish receive begins immediately as they leave the boats. They are hoisted directly out of the vessels onto a conveyor which bears them through a bath of chlorinated sea water. An automatically regulated supply of liquid chlorine gives it a concentration of from 4 to 5 parts per million, sufficient to secure surface sterilization without injury to the fish.

As the fish come from the bath, the conveyor drops them into large and well-scrubbed wooden boxes. The 600 pounds of fish that go into each box are mixed with a small quantity of ice, and are hauled by tractor the short distance to the freezing plant. The boxes at once go into a holding room at 36° F., a temperature far enough above freezing to prevent any surface dehydration of the fish, and yet not so high that melting ice bathes them in fresh water. They remain in the holding room only long enough to even out the supply from the pier to the processing operation; never more than 24 hours, and usually but 2 or 3.

Birdseye "frosted" fillets, as the products of the plant are known, are prepared in two ways. From some, including all those that go into 1-pound packages, the skin is entirely removed by the apparatus shown in Fig. 3. Two men must work quickly to feed this machine, which swings the fillets into proper position and subjects them to the vibrating knife. The skins are cut off cleanly and completely. Less waste results, it is said, than when the fish are skinned by hand.

From a much larger percentage of fish, however, the skin—high in food value and instrumental in retaining flavor when the fish are cooked—is not removed. Fish to be prepared in this way are dumped from the large boxes to bins in front of three scaling machines. In this machine, four wheels equipped with flexible

Fig. 2—After a dip in chlorinated sea water, the fish received on the dock are loaded into boxes for transport to the plant.

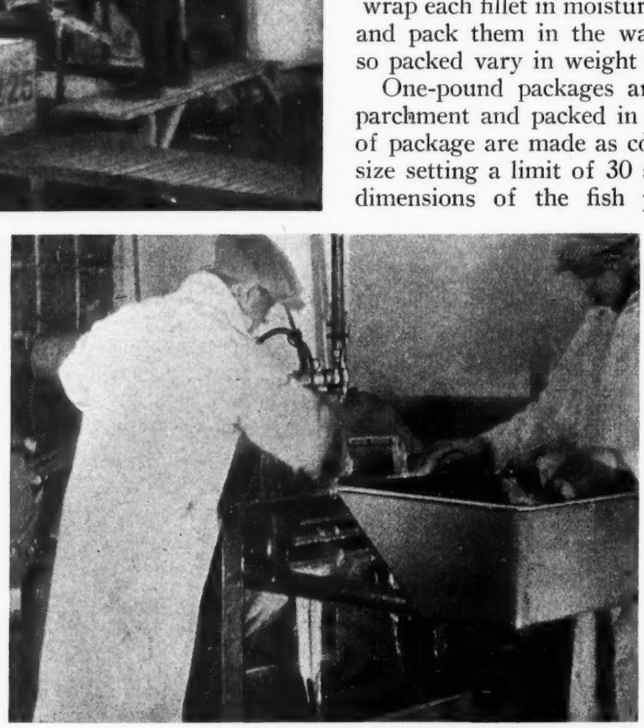


Fig. 3—Two men feed the machine which automatically skins the fish.

bronze strips revolve rapidly over both sides of each fish, in a direction against the scales, as it is conveyed through the machine head first by a hook that holds it at the gills. The spacing and pressure of the strips is such that the scaling is done without injuring the skin of the fish. Throughout this part of the operation, whether it be scaling or skinning, sprays of chlorinated sea water play on the fish.

Before the fish are put into the hands of the cutters for filleting, a conveyor immerses them in chlorinated sea water once more. Boxes containing 600 pounds of fish are emptied on the conveyor, and these batches, after washing, are automatically directed to one of a dozen hoppers that stretch the length of the room. Each hopper opens on a large cutting table of Monel metal at which two men work. Beneath the cutting tables another conveyor carries away the scraps from the filleting operation. The fillets themselves are placed in Monel metal pans, weighed, and taken to the cutter and briner.

The conveyor by which they enter the briner serves also as an inspection belt as they pass up the slope. Only the fish that are to be packed in 1-pound packages—about 10 per cent of the plant's production—are cut by the circular knives to lengths of 5 inches. In the "Cello-wrapped" type, the fillet is retained at its original length.

The function of brining, the next step in the process, is one of particular interest. The 35° (Salometer) brine in which the fish are immersed for 17 seconds has no preserving or "salting" action. After the freezing, however, while the fish remain in storage, this slight salt concentration produces a marked effect upon the flavor of the final product.

Transfer to a weighing table is the next operation. Here the fillets to be packed in 10-pound packages are weighed into circular Monel metal pans holding exactly that weight of fish. These travel on an endless belt before the wrapping tables. The girls who do the wrapping remove the pans as they need them, individually wrap each fillet in moisture- and vapor-proof Cellophane, and pack them in the waxed carton. Individual fillets so packed vary in weight from $\frac{1}{2}$ to $1\frac{1}{4}$ pounds.

One-pound packages are lined with waxed vegetable parchment and packed in a similar manner. Both types of package are made as compact as is possible, container size setting a limit of 30 square inches per pound. The dimensions of the fish packages now in use are as follows: 1 pound, 3x5x2 inches; 5 pounds, $7\frac{1}{4}$x10x2 inches; 10 pounds, 10x15x2 inches.

The packages are automatically wrapped in waxed glassine paper and sealed with a hot iron producing a practically air-tight package. Inclosed air space is exceedingly small, and breathing will take place only with barometric changes of considerable intensity. Finished packages are then taken to the freezing room by means of racks of trays. One end of the tray is left open to facilitate transfer to the rolls. The freezing room is kept at about 32° Fahrenheit.

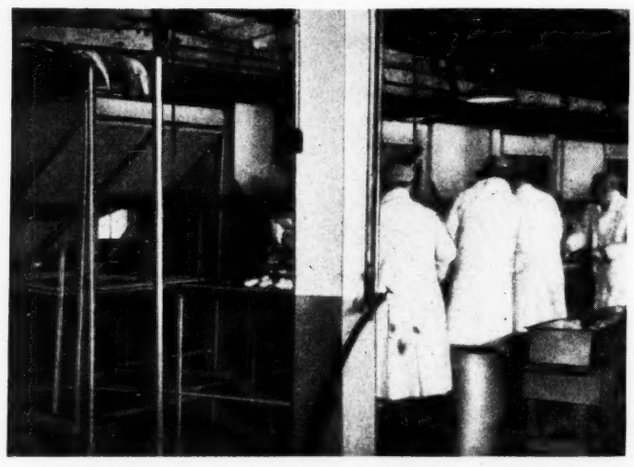


Fig. 4—An overhead conveyor routes the fish to the desired bin between the filleting tables.

The Birdseye freezer, now familiar in general appearance to most of those connected with food manufacture, is shown in Fig. 6. Four endless belts are used on each machine, of which there are two at the General Seafoods plant. There are virtually two freezers in each unit, one above the other, and the boxes of fish to be frozen are placed on the lower belt of each set. These lower belts, which protrude about 6 feet beyond the actual freezing area to aid in loading and unloading, act both as con-

veyors and freezing contacts. By means of a set of rollers located above the upper belts, the weight of the belt, and the tendency of the product to expand while freezing, a controlled pressure of several pounds per square inch is imparted on the package, giving excellent contact and retaining its rectangular form.

Actual freezing is done from both sides of the package simultaneouly. Brine at a temperature of —45° to —50° F. is sprayed on the reverse side of each belt where it comes in contact with the package throughout the 50-foot length of freezing area. The belts are composed either of Monel metal or stainless steel, both kinds now being in use at the plant, and are, of course, more than 100 feet in length. The lower belt is 36 inches wide and the upper 44 inches. When in operation, the edges of the upper belt flex downward and cause the brine to flow off at both sides to the insulated tank below. At the end of travel of each belt, a tray containing salt brine and alcohol is contiguous to the belt, and a brush rubs against it. This cleaning feature comes into particular use when unwrapped products are frozen.

The apparatus is suitable for either continuous operation or batch operation, depending upon the uniformity of the types of packages and character of material. When used as a batch machine on 10-pound packages of fish fillets, the packages are placed three abreast with the 15-inch side parallel to the belt. In the 50 lineal feet of freezing area, therefore, 120 packages, or 1,200 pounds, can be placed at one time, the two belts which make up one unit giving a total of 2,400 pounds per unit. Two virtually similar units are in operation. With a speed of freezing suitable for this product and package, the production totals 1,200 pounds per hour for each unit. These units are operated 24 hours a day when the supply of fish warrants.

Refrigeration for the freezer is supplied by a carbon dioxide system of 50 tons, although the total installed capacity of the plant is 70 tons. The compound compressor, which supplies carbon dioxide at a pressure of 800 pounds per square inch to cool brine for the freezer, is driven by a 225-horsepower synchronous motor.

The smaller compressors furnish refrigeration which maintains the storage room at a temperature of about —15° F. This room has a storage capacity of 500,000 pounds of fish. It is completely insulated with an 8-inch wall of cork, and is entered only through a double door. Every precaution is taken to maintain it at an absolutely uniform temperature. In this room the packaged fish is stored in 150-pound wooden boxes, previous to packing in insulated shipping containers.

These containers are composed of a corrugated cardboard box lined with four or more layers of corrugated strawboard, depending upon the size of the box. A test of heat-transfer rates showed that strawboard-insulation is the equal of cork or balsa wood for this purpose, and

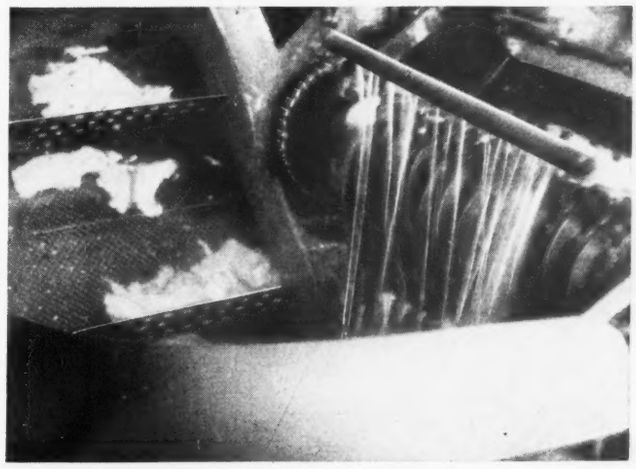


Fig. 5—Repeated washing and spraying assure absolute cleanliness.

the cartons may be shipped by express to all parts of the country without additional refrigeration. They are tightly sealed by machine to prevent entrance of air and consequent condensation of moisture and frost.

An analysis of costs shows that the lining of the 1-pound packages amounts to 0.10 cent per pound, the carton 0.50 cent, and the waxed wrapper 0.14 cent, giving a total of 0.74 cent for material costs for the unit package. The shipping container for these packages (50-pound size) costs 22 cents, or 0.44 cent per pound, bringing the container costs to 1.18 cents per pound. The "Cello-wrapped" fillets that are individually wrapped and packed in 10-pound packages reduce this cost considerably.

It is estimated that refrigeration costs, including power, overhead on machinery and plant, and personnel, aggregate about 0.75 cent per pound. Costs for the process, therefore, exclusive of cleaning, filleting, and labor costs for packaging, total 1.93 cents per pound.

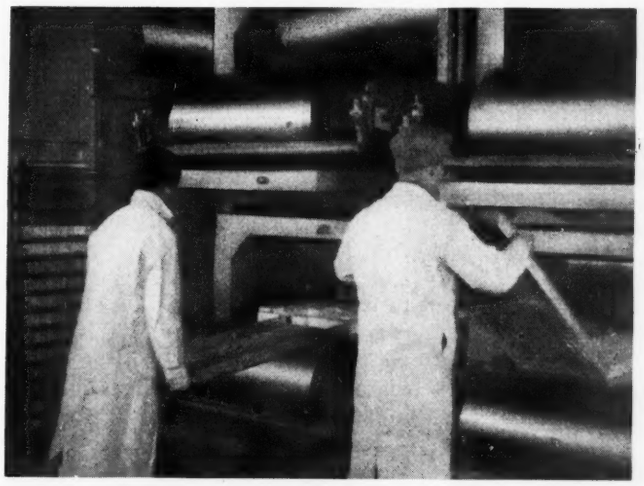


Fig. 6—The packaged fish are slid from trays onto the moving belts of the freezing units.

Freezing of Fruits and Vegetables Requires More

RESEARCH

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THE EFFECTS of freezing upon plant and animal tissues probably were observed by man for centuries before the usefulness of these phenomena in his daily life came to be realized. Practical utilization of refrigeration in connection with foodstuffs began in historical times when the use of atmospheric low temperatures, ice, and snow for the cooling of foods and drinks to temperatures that make them more palatable and retard deterioration and the development of organisms causing spoilage.

It is only recently, however, that progress in mechanical refrigeration, together with changes in food-distribution practices, has brought preservation by freezing into striking prominence. Now almost any discussion of foodstuffs gravitates toward a consideration of the future possibilities of freezing, and the most optimistic predictions are readily accepted.

A conservative examination of the facts already assembled by research and experience, on the other hand, probably will reveal that many technical problems are as yet imperfectly understood, that the solutions offered for many of these problems are matters of opinion rather than of established fact, and that preservation by freezing is indeed a useful and promising, but not unlimited, means for the wider and more satisfactory distribution of certain foods.

In the consideration of fruits and vegetables, especially, research seems to be particularly essential at present, for no young food industry can hope to develop without many costly mistakes if it ignores the technical foundations upon which it rests. Such research calls for the abandonment of all preconceived notions or popular assumptions; it calls for the time, money, and man-power for a careful search of the literature of past experimentation; and for further experiments based upon sound and fully developed theory, if the potential value which the frozen-pack industry possesses is to be realized as quickly as possible.

Group Action in Research Desirable

It is highly desirable that frozen-pack research be undertaken by groups, rather than by individuals, because some of the aspects of the problems are so complex as to be quite beyond the training or mental grasp of any one individual. At present it is perhaps too visionary to entertain the idea of a group of research workers devoting their energies only to frozen-food problems, similar to the group of able scientists of the National Canners' Association who study and solve problems of the canning industry. Eventually, it would seem that a concentrated frozen-pack research body could deal more effectively with fundamental problems than can the valuable, though necessarily more diffuse, attacks now made by different and detached organizations.

It is the purpose of this discussion to consider a few of the factors which seem essential to the satisfactory development of frozen-pack fruits and vegetables for distribution in small containers. It should be remembered first of all, that the freezing of fruits in large containers, such as the 50-gallon barrel, is already a well established business. It is not entirely devoid of problems, of course, but it certainly is possessed of greater experience than the small-container pack.

Maturity of Raw Material

Maturity of raw material is a matter of primary importance, not only in obtaining an attractive, agreeably flavored product but because there is evidence to show that surface oxidation and discoloration, among the most serious of frozen-pack problems, may be diminished.

It seems that full maturity in fruits is more important in frozen-pack than in canned products, because the heat-processing may cause changes in tissue constituents and texture that may mask, more or less, the original immaturity of the raw material. More specifically, this means that white-tip strawberries; raspberries which cling to the stem; poorly filled, sour blackberries and loganberries; poorly colored astringent cherries; green apricots and peaches; and other fruits in similar stages of immaturity, should be as rigidly excluded from the pack as if they were decomposed. It is true that modifications in packing procedure may often reduce this oxidation and discoloration susceptibility, but this fact does not minimize the importance of maturity.

Rather closely allied to this factor is the question of varietal adaptability to frozen-pack. Fruit and vege-

table varieties, as well as kinds, differ considerably in their behavior when frozen and thawed. Although a certain variety of fruit or vegetable may display undesirable characteristics as a result of this mode of preservation, other varieties may be more satisfactory in this respect. In any event, varieties that are most suitable for frozen-pack may not—in fact, often do not—grow everywhere in the country with equal productiveness. The ultimate choice of raw material, therefore, will be based upon a composite of several factors of production, adaptability, quality and cost.

Type of Container

The question of the proper container for frozen pack is indirectly related to basic problems of frozen-fruit physiology. Of course, the choice is determined in some cases by the use of a specific freezing process. In general, however, decision is based upon such elements as relative cost; ability to prevent passage of oxygen, water vapor or odors; ability to resist decomposition, staining, or absorption of water on thawing; rate of heat transfer; ease and perfection of closure; sturdiness of construction and appearance.

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In so far as paper, glass, and tin are concerned, the choice of either of the two latter materials may be determined by a desire to vacuumize the container. For some horticultural products, such as cherries, which discolor very readily, this may be desirable, but it seems to be necessary in any event to prevent contact of the fruit with oxygen after the vacuum is released and the package is opened by the consumer. This has been rather satisfactorily accomplished for fruits by the use of sugar or sirups sufficiently high in concentration, employed in such a manner as to keep the fruit submerged or coated. Where sirup and sugar packs of fruits of comparable concentration have been compared, the sirup has invariably been more desirable.

The effectiveness of these methods will, of course, vary with the fruit, and they are least satisfactory with such fruits as apricots, peaches and sweet cherries, which discolor very readily. Naturally, both sirups and vacuumization can sometimes be used together very effectively. However, with fruits, such as the various berries, their effect is not necessarily additive when they are both employed. There is evidence that when a sufficiently concentrated sirup covers fully matured berries as soon as they are packed, their color may be retained satisfactorily in small containers.

With some fruits, the presence of cane sugar in the pack appears to aid very materially in color and flavor retention, and with the use of sirups there may be brought about, through osmotic action, certain alterations of tissue character which conceivably may benefit the texture of the fruit before water is withdrawn by crystallization in freezing.

Rapidity of Cooling and Freezing

Emphasis of late has been laid so strongly on the benefits arising from rapidity of cooling and freezing that popular attention has been directed more and more to this element of speed. Regarded with scientific impartiality, it does not seem necessary, for instance, to assume that rates of cooling and freezing desirable from the standpoint of fruit or vegetable product quality become doubly valuable when they themselves are doubled.

In dealing with living material as variable in character as plant tissue, the fact must be kept in mind that alterations in environmental conditions produced to bring about certain desirable changes may, if carried too far, cause additional changes of questionable desirability. *A priori* reasoning, which takes for granted that the physics and chemistry of plant tissue freezing are the same as those which characterize the freezing of animal tissue, may be accepted in the interests of conservation of mental effort, but it does not necessarily develop facts.

Research has demonstrated that ice crystallization in plant tissues ordinarily begins not within the cells themselves but in the intercellular spaces, where the ice crystals may grow further in size through crystallization of water, withdrawn from the living protoplasm of the cells. This process may continue until cell shapes are pressed and distorted by the ice masses, and in rapid freezing at very low temperatures there may eventually occur a rupturing of the cell walls. Inherently, however, the freezing of plant tissues is really a drying phenomenon, due to the more or less rapid withdrawal of water from the cell contents to the crystallization foci in the intercellular spaces.

The physiological character of these cell contents may in some cases be irretrievably altered, so that the living material of which they are composed takes on a changed permeability to tissue juices, and leaking of the latter then occurs. Some of the tissues, or portions of them, may eventually die as a result of the changes brought on by freezing and undergo chemical decomposition. In all of this, the piercing of cell walls and mass-crushing of protoplasmic materials by growing ice crystals probably plays a less important rôle than is popularly supposed.

Importance of Microbiological Research

The problems of bacterial and fungal decomposition and spoilage obviously are of primary importance in any form of food preservation. In so far as frozen fruits and vegetables are concerned, some information of a more or less general character concerning the behavior of yeasts and molds has been developed in the past. This knowledge, however, seems inadequate when one realizes that little or nothing is known of the types and species of fungal organisms involved, of their prevalence as related to climatic conditions, and of their physiological behavior in the environmental conditions prevailing during the preparation, freezing, and thawing of frozen-pack fruits and vegetables. It is known, of course, that temperatures below 40° F. cause a marked reduction in their activity, which finally ceases when complete freezing has occurred. Something is understood, too, of the relation of their multiplication and functioning in the carbon-dioxide and oxygen concentrations that prevail in containers as a result of the respiratory activity of the fruit tissue and of the organisms.

The relations of growing conditions and packing-plant

procedure to microbiological development in fruits and vegetables designed for frozen pack, where positive heat preservation is, of course, absent, has not been studied, and their possible significance is only rarely appreciated.

Bacterial behavior under conditions involved in freezing is an imperfectly understood field. With fruits, this fact may not appear so essential, but in the case of vegetables, it will be necessary to obtain positive assurance by adequate experimentation that there is no possibility of danger to human health, if the future of frozen pack is to rest on a secure and lasting foundation. It is conceivable that vegetables can be packed and frozen in such a manner as to minimize any danger, but that is not enough. There must be unquestioned assurance of safety even under the conditions that may prevail when the package is in the hands of the consumer, because his or her activities are beyond the control of the packer, even if proper directions for utilization are placed on the package.

Development of Handling Facilities

Due to the youth of the small-container, frozen-pack industry, equipment for handling this commodity on a volume basis is not yet developed. Presumably, if it follows the trend set by other food industries, we can look forward to a considerable mechanization of the handling processes, which now involve a relatively high proportion of hand labor, as far as fruits and vegetables are concerned. There undoubtedly is a growing appreciation among packers of frozen products that methods which were, and perhaps still are, useful and satisfactory for preparing frozen pack in large containers do not necessarily lend themselves equally well to the small container.

Mechanical refrigeration is, of course, the cornerstone upon which the frozen-pack industry rests, although proper recognition must be given to the importance of refrigerants, such as solid carbon dioxide, in the ultimate distribution of the frozen product. Insulation, whether accomplished by materials or by the principle of the Dewar flask, immediately becomes an essential corollary of this concept.

In order to appreciate properly that service which refrigeration must provide in the cooling and freezing of fruits and vegetables, it is well to recall that three objects, at least, must be accomplished: (1) The so-called "field heat" must be reduced; (2) the heat of respiration, which is an appreciable factor at higher temperatures, must be removed; and (3) the heat of fusion, which occurs as a result of ice formation, must be dissipated.

Accepted Temperature About 0° Fahrenheit

As general commercial practice for fruit and vegetables at the present time, cooling and freezing at temperatures centering about 0° F. seem to be most commonly accepted and based on the best information now available. With adequate refrigerating capacity available, the problems of sufficiently, but not excessively, rapid cooling of small containers should be relatively easy of solution, if some methods can be devised to cool them individually after packing, rather than after they have been assembled in cartons or boxes for shipping, as is generally done at present.

These packages naturally insulate their contents, more or less, against heat transfer, even when every care is taken to see that refrigerating efficiency is encouraged. To cool and freeze fruit in small containers protected in this way seems to be an uneconomical and primitive practice, and one which invites distinct improvement. It seems highly desirable, however, once the fruit or vegetable is frozen, to utilize the insulating character of cartons and boxes by then packing the containers in them, preparatory to storage or shipment.

Slight Motion Aids in Freezing

It seems reasonable also to assume that a better frozen product will be obtained more readily if the fruit or vegetable mass, with its accompanying sirup or juice, is kept in slight motion during cooling and freezing. In this way, sirup or juice distribution will be uniform, heat transfer will be facilitated, and ice crystallization will be encouraged. The methods by which this cooling and freezing are to be more cheaply and efficiently done need not be considered in this discussion. It is sufficient to say that their devising does not present insuperable technical difficulties, although it will take time and research.

If these results are accomplished, it is possible that extremely low temperatures will not be required to refrigerate and preserve frozen pack properly. The economic advantage of this possibility, regarded from a refrigeration-cost standpoint, is too obvious to require elaboration.

The repackaging of frozen-pack fruits and vegetables in the consuming markets has given rise to considerable discussion during the past year. The experience gained by investigators and by the trade probably is too immature at present to warrant positive declarations about this type of frozen-pack business. However, there is a belief shared by many that eventually the packing of small containers will be done to best advantage in the producing sections, where the details required for a high-quality pack can be attended to more easily and with perhaps greater success. Until this question can be answered in experience and time, every effort should be made by the frozen-pack industry to insure repackaging only under such conditions as will give a product that will attract and please the consumer. It is vital for the future of frozen pack to emphasize at this early stage of its development that an unsatisfactory repackaged product will have a lasting effect on the consuming public, as the first impression of a new method of food preservation.

Economic Justification Necessary

Frozen pack of fruits and vegetables should have some better justification for a permanent place in the modern food-distribution scheme than that mechanical refrigeration is generally available today in the warehouse, the store, and the home. Only for horticultural products for which one can present such economic reasons as better quality, wider distribution seasonally or geographically, and lower cost of preservation and distribution, is frozen pack a justifiably economic method of preservation.

Until a reasonably certain program is developed by research and by business organizations in the essential phases of frozen pack, a policy of common sense and of gradual, conservative expansion, where expansion is justifiable, probably will serve the whole food industry better, lead to fewer mistakes and less wasted effort, and ultimately place the frozen-pack industry on sound technical and financial basis.

Why QUICK-FREEZE?

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—Blank-Stoller, Inc.

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THE THEORY OF FREEZING is interesting. It is a study of the reactions of tissue substances in solidification when subjected to low temperatures. Although scientists do not agree as yet on exactly what happens in all details when cellular material with large water content freezes, the major reactions are quite obvious and may be epitomized in a paragraph, fish being used as the best known example.

The flesh of fish, consisting of 60 to 82 per cent water, is made up of millions of microscopic cells. Likewise, the gelatinous content of these cells is principally water. When fish is frozen slowly, the water has a tendency to separate from the jelly in microscopic ice crystals, and as freezing proceeds the water diffuses out of the jelly to build these crystals larger and larger until finally a great portion of the water has separated out as ice. These crystals—long, sharp needles—rupture the delicate cell membranes, with the result that when the fish is defrosted, the juices run out freely through the lesions, and with the juices goes much of the flavor or toothsomeness.

On the other hand, when fish is frozen with extreme rapidity, the cell substance solidifies as a mass of frozen jelly. One of the reasons advanced for this is that the tissue freezes so quickly that large ice crystals do not have time to form before the mass is solidified. The crystals are so minute and compact that they are easily contained by the elastic cell walls, without rupturing the tissue. Another reason given is that, due to the speed of freezing, the osmotic action that normally would take place through the cell walls, and the consequent dehydration of the cells, is decreased noticeably. The water content of the cells does not separate from the cell solution, but freezes as a frozen jelly into a waxy, non-brittle solid. The resultant product retains most of the texture and flavor of fish fresh from the sea.

This being a practical discussion, and not a scientific one, the foregoing may be taken as the popular conception of the distinction between slow and quick freezing.

The technical factors of most importance in quick freezing are contact, agitation, and temperature, the last being by no means all-important. As to the importance of contact in the freezing of fish, an example may be cited of the process that uses merely salt and ice. The method is at least 40 years old and it is still extensively used. By applying layers of salt and ice, in the proportion of 2 tons of ice and 600 pounds of salt to a ton of fish, freezing is accomplished in 6 to 8 hours, producing blocks of fish 2½ inches thick. Why is it that although melting ice and salt does not exceed 0°F., the fish freezes much more quickly than it does in a direct-expansion freezer with the freezing pans placed on coils, and probably three times as fast as if it were placed in a freezer room at — 20°F. with overhead coils and without air blast?

The answer, of course, is that conduction is a much more effective method of heat transfer than is convection, the wet brine contact conducting the heat away much faster than air can carry it away. Similarly, we found in our experiments with direct-expansion shelf coils that the contact of the iron pan with the ammonia pipes did most of the freezing, and that the contents of the end of a pan extending beyond the coils were not frozen.

Circulating the air accelerates freezing noticeably. In the fishing industry, however, an air blast is considered not as a basic principle but as merely an aid to quick freezing. Air is difficult to handle and acts peculiarly. No matter how it is used, the expense of providing such refrigeration usually equals the cost of brine quick-freezing equipment, and seldom results in real quick freezing, for the product has to be heavily wrapped to protect it from that type of localized dehydration known as freezer burns.

Bearing in mind the interdependence of contact, agitation, and temperature, it is interesting to follow the principal steps in the development of quick-freezing. The earliest method was direct immersion. The materials to be frozen were placed in a solution of sodium chloride, which was then subjected to agitation. Although this process froze the materials more quickly than any other process we have today, it is now seldom recommended, because of the ill effects of brine penetration from the direct contact.

Next came the step in which the product was frozen by indirect contact with the liquid freezing medium by

means of a container of good heat-conducting qualities. In each of these cases a liquid freezing contact and good agitation are maintained.

Indirect-contact brine freezers are of two classes, rendered necessary by the demands of the market. They are designated as "double-contact" and "single-contact" freezers. As is well known, the rate of heat transfer through material to be frozen bears an inverse relationship to the thickness of the substance. Thus, freezing proceeds inwardly at a decidedly reduced rate. It is apparent that when thick objects are to be frozen, contact should be made with both principal surfaces, top and bottom. On the other hand, a thin steak, fish fillet, and the like will freeze within the time limits of quick-freezing without the necessity of freezing from both sides.

Freezing Equipment Depends on Package Chosen

The two principal types of packages used with fish are the block-frozen package and the individually frozen package. The choice of package determines the selection of freezing equipment. The solid block requires a two-surface or "double-contact" type of freezer. The material is handled in the form of a block that may be frozen either before or after it is inserted in the package. As all air is excluded by the pressure exerted during freezing, a compact package is possible. Material packaged in this way stows away efficiently in warehouses, in refrigerator cars, and in trucks during distribution. The most outstanding advantage of the block package is its ability to hold its refrigeration under conditions of distribution for a long period of time. With little or no air pockets, the thawing action is very slow.

The chief drawback to the block package can be remedied at a little extra cost. The drawback is that the whole block has to be thawed before the units comprising the package can be separated from one another. However, if each cut of fish or meat is wrapped separately before being pressed into the block, it can be removed after freezing as an individual unit. It has all the advantages of an individually frozen cut, except that its shape is distorted from the pressure, but not objectionally so.

The individually frozen package requires the "single-contact" type of freezer. In this method, used with at least 75 per cent of the quick-frozen packaged fish now being marketed, the cuts are frozen separately and later put in packages. As thin objects freeze more rapidly than thicker ones, brine of a relatively high temperature may be used for this type of package, thereby cutting refrigeration costs. Other advantages are that sorting and grading of the finished product is facilitated and that systems of quick freezing by the "single-contact" method are simple to operate. More plants of this type are in use than of the other kind.

There is much disagreement on the specific points of how quickly flesh must be frozen to gain the greatest good from the quick-freezing process and what temperatures produce the best product. In the field of packaged fish there are offered products frozen in from 20 minutes to 2 hours, with temperatures ranging from 0° F. to —50° F. The market absorbs them all, recognizing few differences in quality; yet in the Middle West, fish that have been frozen rapidly are sold to the almost total exclusion of the slowly frozen product.

Apparently, quick-freezing is an application of that law of nature which permits some of the cold-blooded animals to freeze in winter, and thaw and live again in the spring; at least, there is considerable evidence to that effect. If this could be proved, it would demonstrate the possibility of a considerable range of freezing time and temperature.

Further experimentation will add to present-day knowledge of the scientific aspects of quick-freezing. Meanwhile, one will find that most products put out under the generally accepted limits of quick-freezing vary but little in freezing quality or in salability, and that they all show a very real superiority over the slowly frozen product. Fish are not produced under ideal conditions and necessarily call for more attention than do meat products. The differences which do exist are in the refinement of the package and the treatment of the cuts before freezing. Some dip their fish product in ordinary salt brine; one firm advocates special liquid processing before freezing; and some do no processing at all.

Many keen minds are constantly searching for new basic ideas on quick-freezing and, no doubt, excellent suggestions will be offered in the coming years. Tests that should be used to determine the worth of such ideas include the following:

Does the quick-freezing system freeze quickly?
Does it allow for expansion of the product?
Can the product be taken out of the container easily?
What is the appearance after freezing?
How does the material keep in storage after freezing?
Is the material dried or freezer-burned?
Will it handle a variety of products?
Is its freezing capacity commensurate with the cost of the equipment and the space it occupies?
Is the upkeep high?
Is the labor cost excessive?
Is the refrigeration cost excessive?

Naturally, the foregoing questions are equally appropriate in testing the worth of all existent systems. Although the points mentioned are important, those pertaining to labor cost of operation, refrigeration, investment, and space required, are especially important. The matter of labor cost per pound of product is most important. A royalty of even as little as $\frac{1}{8}$ cent per pound is by no means welcomed by those who operate plants. Yet, unless equipment is carefully selected or developed, a royalty of as much as $\frac{1}{4}$ or $\frac{1}{2}$ cent per pound may be incurred, chargeable to inefficiency or waste.

The amount of space required may not be so vital a question now as later, should expansion be desirable. Refrigeration cost may not be as noticeable as that of labor, but it should be borne in mind that extremely low temperatures, although often desirable, cost more to obtain, and that the capacity of the refrigerating machine is reduced in keeping with low-suction pressures.

Refrigeration in Distribution

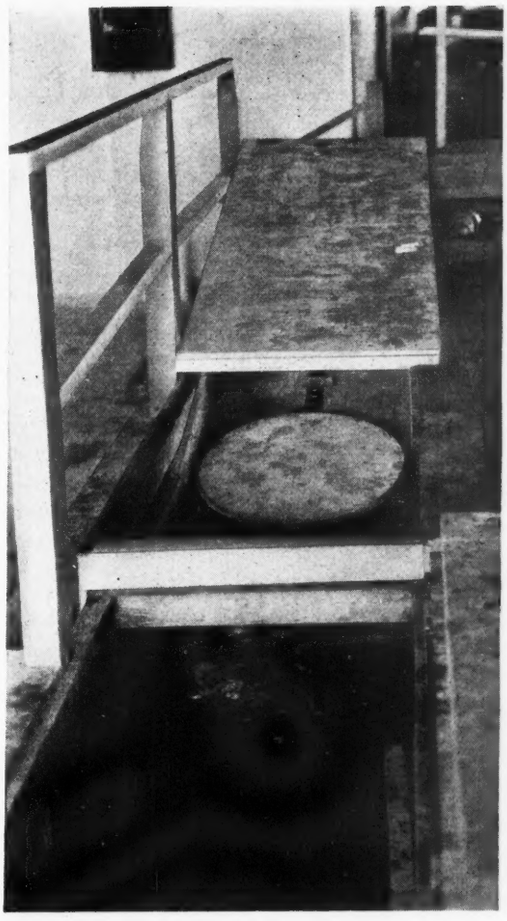
Properly refrigerated cases undoubtedly are on their way and will soon add greatly to the convenience of marketing frozen foods. Under the circumstances, there would seem to be no justification for holding frozen meat back until the cases are supplied. Advances in providing cold-temperature equipment for use in retail stores may reasonably be expected to follow rather than precede the quick-frozen product on the market.

More than 15,000,000 pounds of quick-frozen packaged fish was produced in 1929. Although fish are decidedly more subject to rapid spoiling than meat, most of this large production was marketed without the aid of any special equipment not already available for the distribution of packaged meat. Few realize the amount of

refrigeration stored in a package of frozen material. A frozen package of the block type, particularly when shipped in an insulated container, will hold its refrigeration for long periods of time under relatively severe conditions.

Because of refrigeration requirements during distribution, it seems wise to consider the market for the product before deciding on the type of package. This choice should be governed somewhat by the ability of the product to hold its refrigeration. For city sales, where daily deliveries are the rule, the individually frozen package of cuts will be popular; where much out-of-town selling and shipping is done in small lots, the solid-block frozen package would in most cases insure better condition upon delivery.

So far, the fish industry is the only one that has felt the stimulus of quick-freezing. For a discovery of such promise, its growth has been strikingly slow. Although, it has been known for 30 years or more, for not more than 5 years has the fish industry realized fully the value of quick-freezing. The systems used in the past put an extra cost on the fish so frozen, gaining at best but a preference for added quality. Often, the wholesaling channels forced all frozen-fish prices to practically the same basis, regardless of quality of the product.



A Kolbe "floating pan" emerging from the brine raceway at the Gorton-Pew plant at Gloucester, Mass. **(See page 169)**

However, the years of experimentation have brought better processes and a realization of the fact that, with a high-quality product rendered practically imperishable, new markets and new channels of distribution could be found for fish products packaged in the modern manner. In many localities it has doubled the consumption of fish. Packaged quick-frozen fish are being sold by distributors who previously could not have considered such a product.

Packaged frozen fish have made brand advertising possible, freight shipments the rule, and have taken much of the fluctuation out of the daily prices hitherto found on the large Eastern fish exchanges. Fishing in New England is once more a profitable venture, and shipyards are fast augmenting the fleet that plies the world's greatest fishing banks.

Interesting economic factors are certain to be repeated in other industries if quick-freezing be adopted. The very few large companies that were active in the early days of the development appointed exclusive dealers for city and territory distribution, with the result that the progressive distributor thus selected had a practical monopoly of fish satisfactorily packaged. Because of the widespread demand, retailers were often induced to buy a complete line of fish in order to get their share of packaged New England haddock fillets. Other wholesale distributors in the same city, in some instances, lost fully 50 per cent of their business. Since the advent of other brands of quickly-frozen packaged fish, this is being slowly regained.

As to the producing companies themselves, the pioneers in this development rose from a position of minor importance to undisputed leadership in deep-sea fishing. In a period of 5 years one firm undoubtedly increased its production of haddock and ground fish eightfold and enlarged its fleet of 3 or 4 ocean going trawlers to 20 or more; and their great need is a still larger supply of fish.

This, then, is the experience to which other industries may refer for their conclusions regarding the value of quick-freezing. The experimental stage is not yet past, of course, and the rejuvenation of the fish industry should be taken by other food producers for what it is worth.

So far, this article has been based upon past experiences gained by close personal contact with quick-freezing and the fish industry. The rest of the story can be only a matter of supposition, but the vision is fascinating in its scope and possibilities.

To the extent that quick-freezing eliminates waste, conserves unused food, reduces transportation costs, eliminates market gluts, makes food non-seasonable, or reservoirs stocks to aid business control, it performs a most useful economic service. On the other hand, quick-freezing might justify itself solely because it offers a package of decided sales appeal, and of convenient size for the housewife. In this connection it is of interest to note the recent announcement by a large concern widely known in quick-freezing circles to the effect that a line of 30 quick-frozen foods would soon be ready for the market. Although few other than experts in quick freezing know much about the quality of frozen foods, it is anticipated that several of our major industries will be affected.

The housewife is educated to packaged foods. She prefers buying well advertised brands of goods of dependable quality. Already, publicity material appearing in important illustrated magazines is influencing her to demand meats in packages. The foresighted packer is improving his equipment and facilities so that any day soon he may be ready to turn out a large part of his production in the form of packaged, frozen, consumer-cuts of meat.

Some of the advantages hoped for by the meat packer are: ability to trademark fresh meats, increased meat consumption, more retail outlets, stabilized prices, temporary reservoiring of surpluses, and more steady plant operation. At present, especially with beef, he must buy from the stock grower whatever is delivered daily, at fairly constant prices, and he must force his carcass

products on the market at whatever price is necessary to move them. With a frozen product, he will have a business control permitting him to reservoir his product and enabling him to sell at cost plus a fair profit.

Offsetting these advantages the packer is faced with added costs of breaking up the carcass into consumer cuts, of freezing, packaging, and wrapping. However, the retention of fat, bones, and trimming for processing in the packing house will result in relatively large savings, estimated to be almost sufficient to meet the foregoing new expenses. Prices to the consumer, it is predicted, will be little or no higher than for non-packaged meats, when eventual economies are effected and the savings in distribution realized. In retail selling it is estimated that economies equivalent to 2½ cents a pound will be made through the handling of packaged meats. These savings are credited chiefly to less store equipment, reduced space rental, and much lower wages of sales help. By ordering mixed cars of carefully selected units of packaged meats, chain stores and large buyers, it is believed, may save ¾ of a cent per pound in the cost of wholesale city distribution.

Already there has been designed a packing-house machine capable of slicing, much more satisfactorily than by hand, 75,000 pounds of pork chops daily. With competition of that sort the retail meat cutter's future seems gloomy indeed. So obvious are the advantages of packaging that one of our largest packers has made the statement that 5 years will see this change realized fully.

Packaging is dependent on freezing; slow-freezing is unsatisfactory. Although much has been learned about this process, many packers are still in the dark as to the resulting product when quick freezing is used. Briefly, the bright color is retained and no dripping is evident on thawing. A cause of the present delay with packaged meat is the belief that the idea is too new to the housewife, and that more consumer publicity is necessary before a demand can be created for frozen goods. That this prejudice is fast being overcome is evidenced by the success of present frozen products.

As a matter of fact, Chicago newspapers frequently carry advertisements of half-page size describing the merits of frozen fish, accompanied perhaps by relatively large advertisements offering frozen strawberries. In the face of the present barrage of publicity, the public can hardly escape becoming frozen food minded.

Frozen Poultry

For many years frozen poultry has been a standard product of good value. Because of differing freezing and storing conditions, however, there has been a wide variance in quality. Quick-freezing has been suggested as a beneficial factor in raising quality. Obviously, packaging in small consumer units is a recognized trend, which the housewife will force upon the trade rapidly. Consumption of poultry is undoubtedly kept down by the inability of the small user to use a whole bird. Half-broiler servings and packages containing birds carved ready for use are already appearing in the market. It is predicted that we will soon be able to buy packages containing "drum sticks" only or all white meat, as preference dictates.

To so package poultry as to avoid damage in storage requires thorough knowledge of containers and methods. As packaged frozen food is more costly than unfrozen, preservation becomes increasingly important. If quick freezing gives even a small advantage in quality, its use is imperative. The advantages due to increased outlets, greater consumption, and diminished retail selling expense shown to be evident in the marketing of packaged meats would apply in similar fashion to packaged poultry.

For several years fruits, such as strawberries, cherries, blackberries, and grapes, have been frozen. Utilized first for jam and preserve manufacturing, their use has spread now to retail outlets in small consumer packages. Frozen grapefruit, figs, and other fruits have been added to the list. The total pack of strawberries is a matter of over 30,000,000 pounds and that of sour pitted cherries, 9,000,000 pounds. One Florida cold-storage company, alone, froze 60,000 gallons of orange and grapefruit juices.

Better Frozen Fruits on the Way

These frozen fruits are good; their sale is increasing. But they are not as good as the industry will ultimately provide. A fruit product more refined as to package, and conserving more of the real flavor and appearance of deliciously ripe fruits will make its appearance. The farmer as well as the consumer will profit. As frozen fruits are scarcely known as yet in most communities, it is evident that this branch of the fruit industry is in its infancy. That a more rapid development has not been shown is hardly surprising when it is realized that hundreds of cars of fruit are still frozen in whole barrels, which require several days to freeze. For retail sales they are later thawed, packed in smaller containers, and refrozen slowly. This method, which would be disastrous with most foods, is possible (though not advisable) with berries only because of a large added sugar content. Experts believe that in the future much of the added quality and flavor will be due to quick-freezing processes.

Not so much use has been made of freezing in the handling of vegetables. Peas, of which a considerable volume are now frozen, are perhaps the outstanding example. They are held in refrigeration until certain other vegetables have come into season, and the various combinations are used for canned soups. The freezing of vegetables has been a very recent innovation and confined chiefly to slow-freezing. If a better flavor is obtained by freezing than by the canning process, what the new methods may accomplish is a matter of considerable importance. Caution has been advised, however, in freezing vegetables until research can demonstrate that dangerous spoilage cannot occur.

Both fruits and vegetables are seasonable and, therefore, subject to serious price fluctuation. Consequently they offer possibilities of increased prices through reservoiring in a frozen condition. It is well known that portions of crops are often left to spoil because the demand forces prices too low to make harvesting profitable. As canning plants are not always available to handle these surpluses, the possibilities of their being handled satisfactorily by the more easily equipped freezing plants point to a future opportunity, especially with those products or varieties which may be proven adaptable to quick-freezing.

Admittedly, the concluding paragraphs of this article are to a large extent visionary. Although experiments have led experts to believe that many of these ideas will eventually come to fruition, actual achievement on a large scale is, of course, still in the future. It seems a safe prediction that the products to be frozen will, undoubtedly, be quick frozen, because aside from added quality, equipment for that method is better adapted to the freezing of goods that are to be packaged. When quick-freezing proves its point in new industries, a revolution in food merchandising will, indeed, be effected.

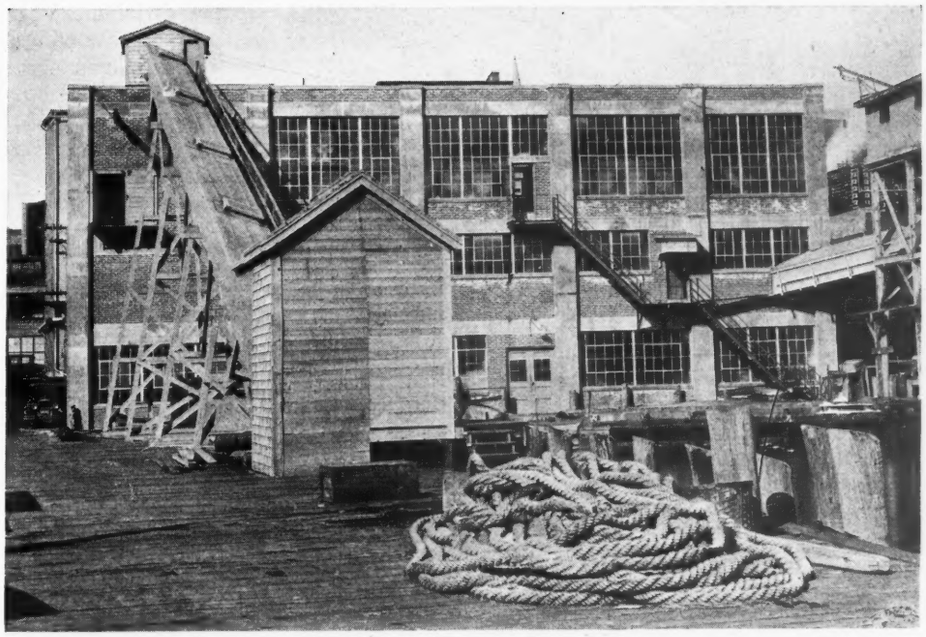


Fig. 1—Gorton-Pew's new quick-freezing plant is built next to the waterfront at Gloucester. Fish are carried to the top of the plant by the inclined conveyor.

A KOLBE INSTALLATION

At the Gorton-Pew Plant

By THOMAS J. CARROLL
President, Gorton-Pew Fisheries Company, Ltd.
Gloucester, Mass.

IN KEEPING PACE with the changing methods of manufacture and distribution the Gorton-Pew Fisheries Company has just completed a new plant at Gloucester, Mass., that is to be devoted entirely to the production of quick-frozen fish fillets. The reasoning that lies back of the decision to enter the frozen-food business involves economics, technology, and merchandising.

Our opinion is that freezing offers the method of preservation that will solve the economic problem of glut and scarcity. Also it makes possible putting out a packaged food under the manufacturer's brand, and we feel that this is an important step forward in the manner of merchandising fish. The decision to quick-freeze rather than slow-freeze is based on knowledge that does not need repetition here.

There remained the choice of the equipment to employ, and after a thorough investigation the Kolbe system was adopted. None of our older buildings was suitable for conversion into a factory that could house the new process under conditions that would permit economical operation, for in addition to the operation of freezing, which in itself is only one of several important steps of manufacturing, there also is the problem of material handling, the problem of producing the requisite refrigeration, and the very important problem of economical preparation of the raw material.

One fact having a very important bearing on the decision to erect a suitable building was that Gorton-Pew owned a suitable plot of ground on the waterfront, with good wharf facilities, which was adjacent to a cold-storage plant of ours. In the engine room of this cold-storage plant was sufficient space for the refrigerating machinery that would be necessary for the freezing plant, thus permitting the same engineer to attend to both units. Also the older refrigerating machinery was sufficient in capacity to operate the cold-storage rooms when the freezing plant was not operating. A further economy, possible to effect by the location of the new plant next to the older cold-storage plant, lay in the choice of an ammonia compressor operated by an Ames Unaflow engine exhausting against 5 pounds' back pressure. The heat from the exhaust is sufficient to operate an absorption refrigerating system that is in reserve at the old plant and it will produce enough refrigeration to

Fig. 2—From the storage bins the fish are conveyed to the water dump in the background, thence elevated to semi-automatic weighing device, and transferred to the skinners.

cool the rooms of the old plant when the freezing plant is in operation. Credit for working out many of these economies is due to our architect, M. P. Vucassovich, and to the York company.

The building, which is not quite rectangular, is 90 feet long and 48 feet wide at one end and 35 feet wide at the other. Distances between three floors are 11 feet 6 inches, 12 feet 6 inches, and 14 feet 6 inches, the last figure being for the top floor, thus reversing the usual order of decreasing floor heights. Storage bins and the filleting department are on the top floor. A glance at Fig. 2 will show why an extra ceiling height is required for the equipment of this department.

Our raw material always comes from the sea. The drag conveyor shown in Fig. 1, extending to a convenient point alongside the unloading berth, conveys the fish, mixed with crushed ice added at this point, to the top of the cypress bins on the third floor. At the bottom of these bins is another conveyor that carries the fish to a water dump which acts both as a washer and a reservoir for subsequent operations.

The filleters work in pairs at stations shown in Fig. 2. Good management necessitates a constant check up on each team's production and this in turn requires weighing the cut fillets produced by them. The dial scales shown in Figs. 2 and 3 show the provision for this function.

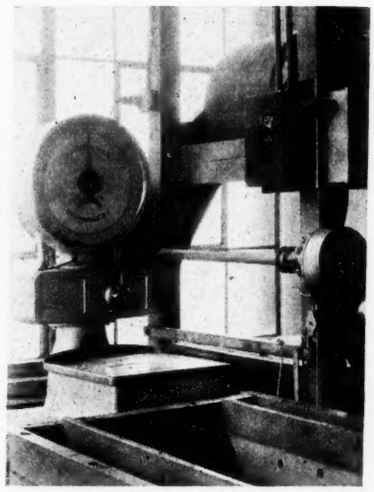
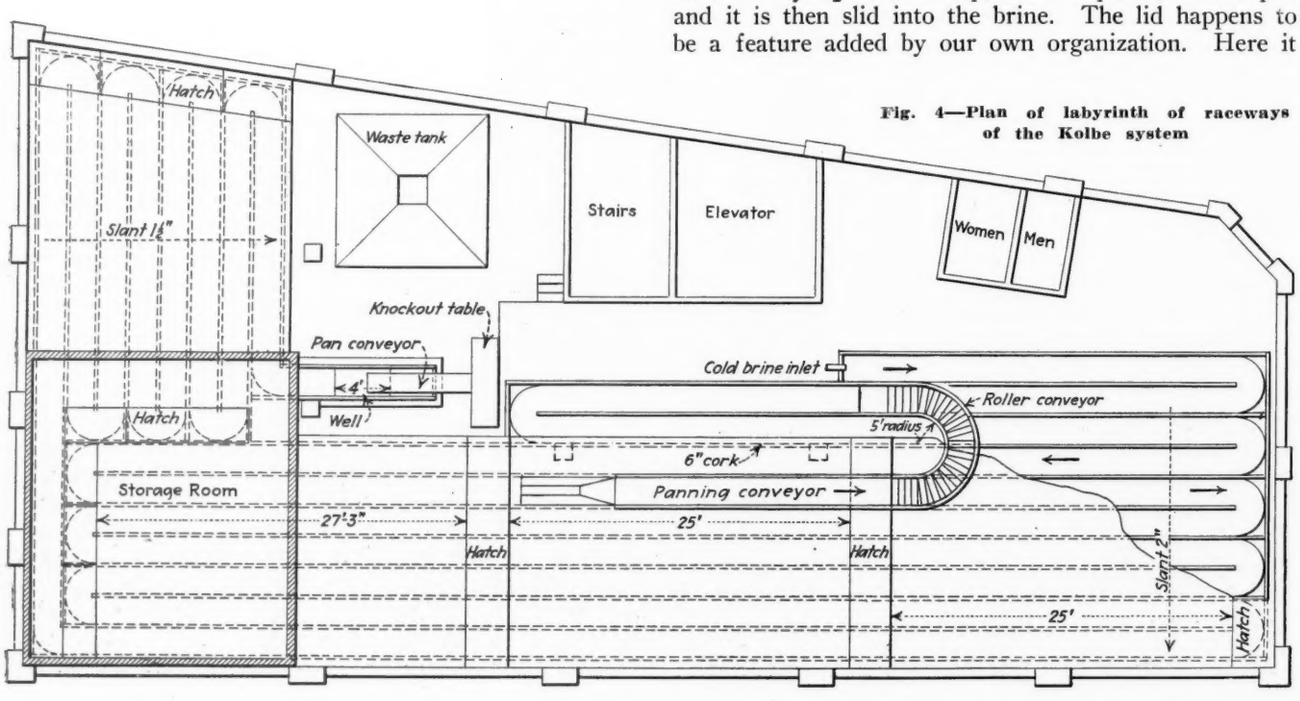


Fig. 3—Cut and skinned fillets are delivered on pans to this scale and are then dumped into the tank in the foreground

After the weighing of the fillets they are given a final wash in chlorinated fresh water containing 4 parts chlorine per million by the apparatus shown in the rear of Fig. 6, and from this point they slide on a metal chute to the panning conveyor on the second floor. (See Fig. 7).

All of the freezing and packaging of the frozen fish is carried out on the second floor. A Kolbe floating pan freezer is a long shallow tank of calcium chloride brine that is kept cooled to —15° F. The product to be frozen is placed in galvanized steel pans 20 inches in diameter by 2½ inches deep, a lid is placed on the pan and it is then slid into the brine. The lid happens to be a feature added by our own organization. Here it

Fig. 4—Plan of labyrinth of raceways of the Kolbe system



floats around a labyrinth of raceways until it emerges at the discharge end with its product completely frozen.

Raceways in this plant are 1,000 feet total effective length. Their plan (see Fig. 4) shows how the course of the brine is led around the peculiarly shaped building and is a testimony to the adaptability of the system. These raceways are above the true floor of the building, and are completely inclosed in cork insulation, with inspection hatchways wherever needed. A double floor above the freezer is the working floor for the room.

Located between the raceways and the floor of the building is 6 inches of cork insulation. A similar layer of cork insulates the top side, and above it is the double floor. This added thickness of raceways, insulation, and flooring, amounting to about 30 inches, is the reason why the ceiling height of the second floor must be greater than that of the first floor.

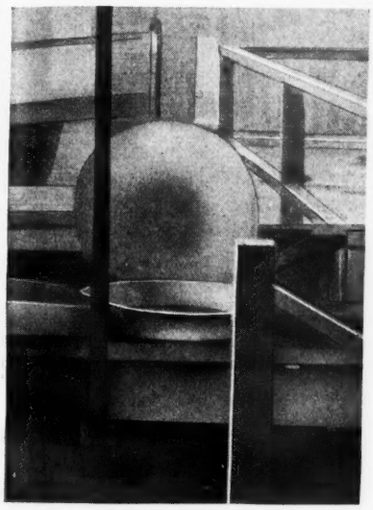


Fig. 5—The Kolbe "floating pan," showing the lid which permits brine to be sprayed from above, giving additional cooling

The operation of laying the fillets in the pans is called panning, and the conveyor where it is done, shown in Fig. 7, is the panning conveyor. As soon as the pans are filled and the lids put on, they are pushed off the end and onto a roller conveyor. This conveyor then lowers them gently into the brine in the raceways. The pan inlet is removed from the brine inlet to avoid placing the pans in a swiftly moving current at the mouth of the pipe.

A 300-gallon per minute centrifugal pump on the first floor, alongside the brine cooler, causes a gentle current through the raceways and floats the pans back and forth until they finally emerge at the point shown in Fig. 9, and are lifted out of the brine by a conveyor.

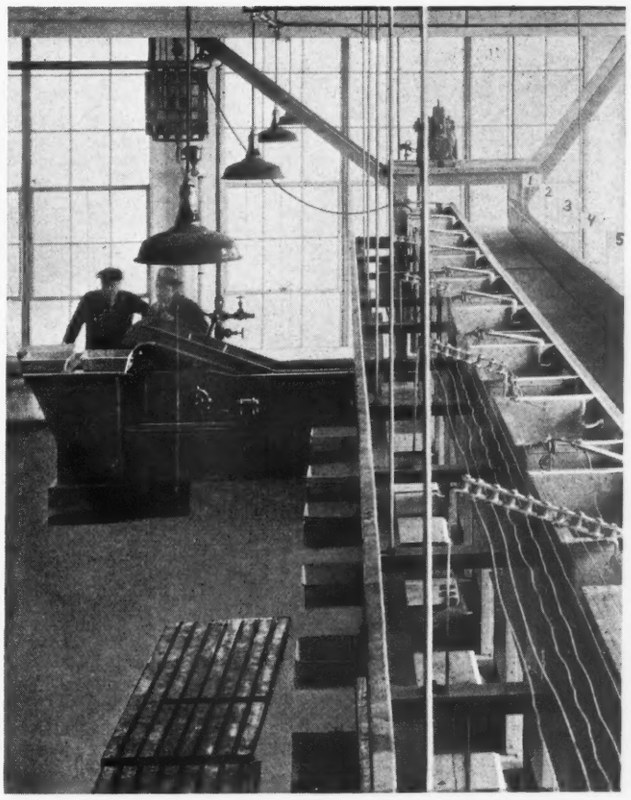


Fig. 6—The last step before "panning" the fillets is to wash them in chlorinated water in the washer in the background

Here an operator knocks the fillets out onto a conveyor leading to the inspection tables; then they are fed to an automatic wrapping machine made by the Package Machinery Corporation. The pans are placed on edge in the rack shown in Fig. 9, which is really a track on which they roll through a spray of water for the purpose of washing them and thence to the panning conveyor to receive a fresh supply of fish fillets.

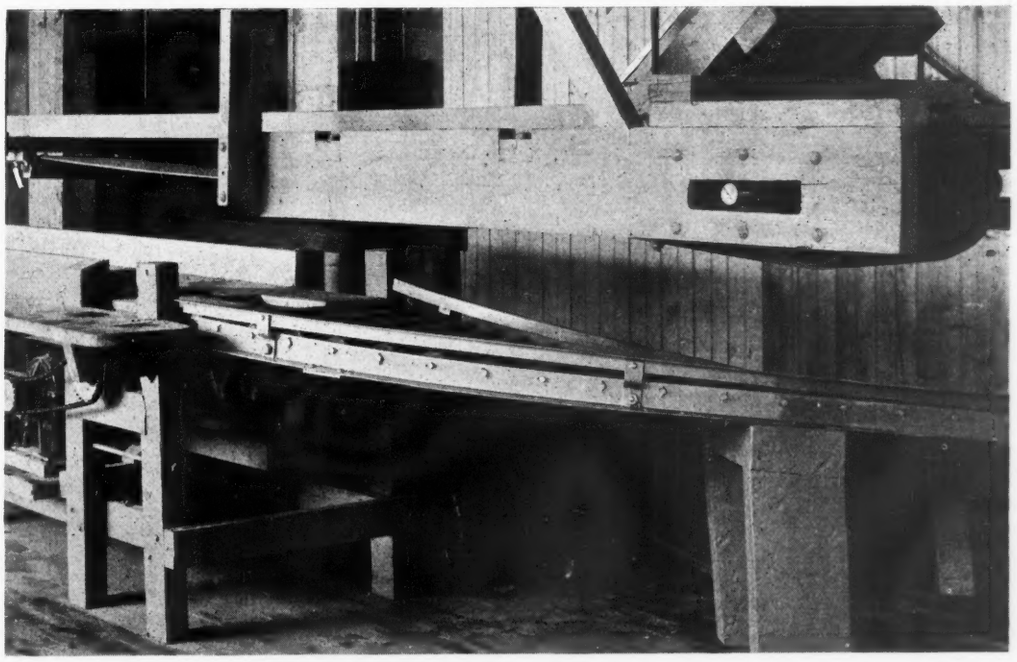


Fig. 7—Washed fillets slide down the chute at the right to the panning conveyor, where they are placed in the Kolbe pans. They are then pushed on to the roller conveyor at the right

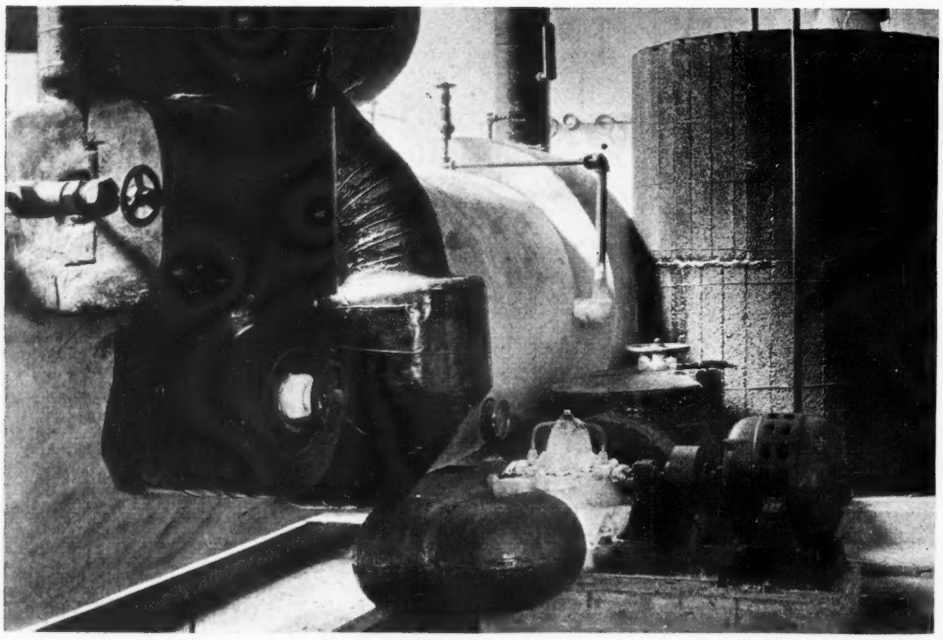


Fig. 8—A 300-gallon per minute centrifugal pump draws brine from the insulated receiver in the rear and forces it through the brine cooler on the left, and thence upstairs to the Kolbe freezer.

At the discharge end of the raceways the calcium chloride brine flows down a pipe into an insulated receiving tank on the first floor, from which it is pumped through the cooler to the beginning of the raceways. The circulation of the brine, an essential feature of the Kolbe system, is maintained by the centrifugal pump, aided by a gentle slope of the raceways as indicated in Fig. 4. The pans are 22 inches in diameter and float in channels 24 inches wide. Naturally, their friction on the sides whenever they strike will retard their motion slightly and will cause their forward motion to be slower than that of the brine itself. This will bring colder brine to each pan than that which has just passed it by.

Each pan holds about 3 pounds of fish and the freezing time is 20-25 minutes, which means that a pan makes the complete circuit of the raceways in 25 minutes. The plant has a capacity of freezing 2,000 pounds of fish per hour. Ordinarily, in a Kolbe floating-pan system the pans have no covers, but in our plant we have employed covers so that we may use a device perfected by Mr. Vucassovich for which a patent has been applied. Refrigerating brine is sprayed on the top of the pans for the purpose of increasing the capacity of the freezing unit. Perforated pipes along the sides of the raceways furnish the spray that strikes the tops of the pans and by this auxiliary, we believe, the rate of freezing is increased about 25 per cent.

Since large quantities of crushed ice are used on our vessels and in storing fish, we have made provision for a 30-ton ice plant on the first floor of the building. This unit will have the effect of increasing the economy of our whole plant by providing more work for the 50-ton York ammonia compressor and in turn this will give us the benefit of its exhaust steam for the operation of the absorption refrigerating systems.

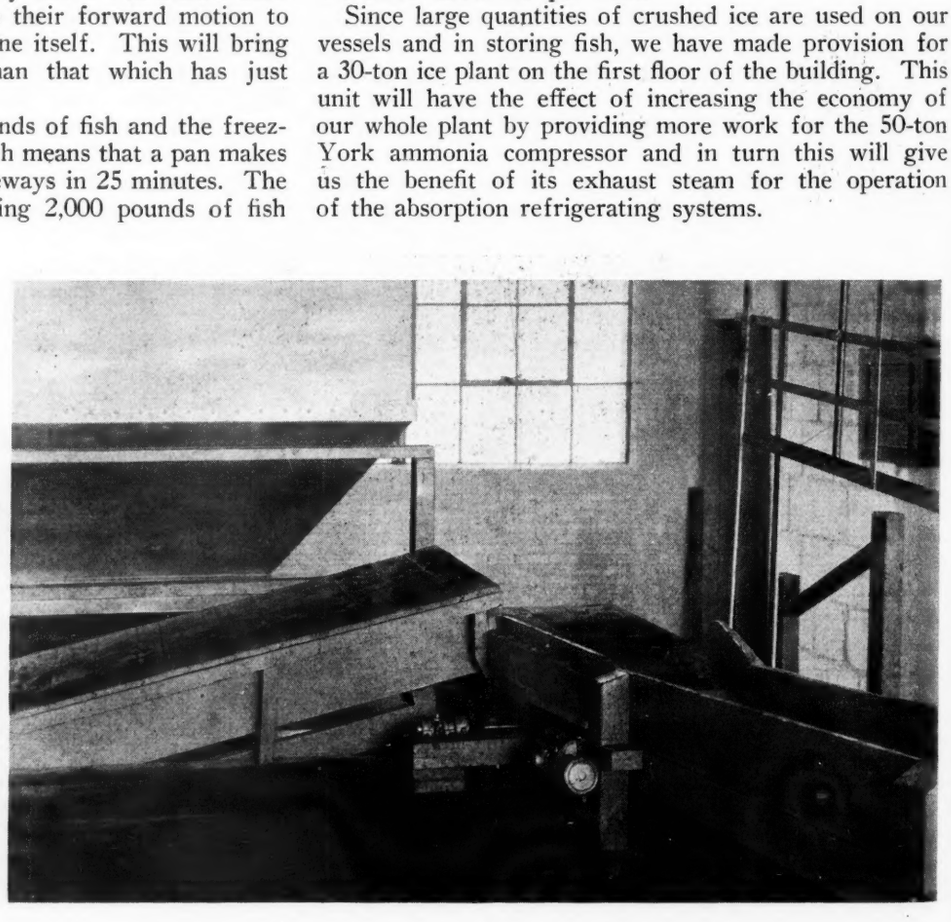


Fig. 9—When finally frozen, the pans emerge from the raceways, passing up the housed, inclined conveyor to the knock-out table. The frozen fillets move up the conveyor at the right, and pans and covers are placed in the track in the upper right corner.

Where the Petersen

RAPID-FREEZING SYSTEMS

Stand Today

Ira L. Hill Studio

Paul Willer Petersen, pioneer in the practical application of quick-freezing, from whom the facts contained in this article were obtained in a recent interview by a member of the staff of *Food Industries*

THERE are times when keeping up to the minute unconsciously distorts one's viewpoint. In the popularization of the newest methods, the newest processes, and the newest products, systems already in successful operation are likely to be neglected. Recent emphasis on the development of individually packaged fish fillets had tended to obscure the fact that modern quick-freezing on a profitable commercial scale has been carried out upon whole and dressed fish for the past seven years.

It is often forgotten, for instance, that more unfilleted fish were quick-frozen last year by the Petersen systems than by any other quick-freezing process, and that freezing plants with a total installed capacity of 130 tons, or more than a quarter of a million pounds, a day have equipment of this type. As the plants are mainly located in the Great Lakes district, where fish freezing is highly seasonal, the quantities frozen annually fall much below the actual capacities of the plants.

Yet the work of Paul Willer Petersen is even more significant than the development of one of the earliest freezing systems would normally be. His work in 1921 and 1922 in demonstrating that frozen products in no way inferior to the fresh were economically as well as scientifically possible, focused attention on the entire subject of quick-freezing and drew to it most of the other minds that have since become instrumental in its advance.

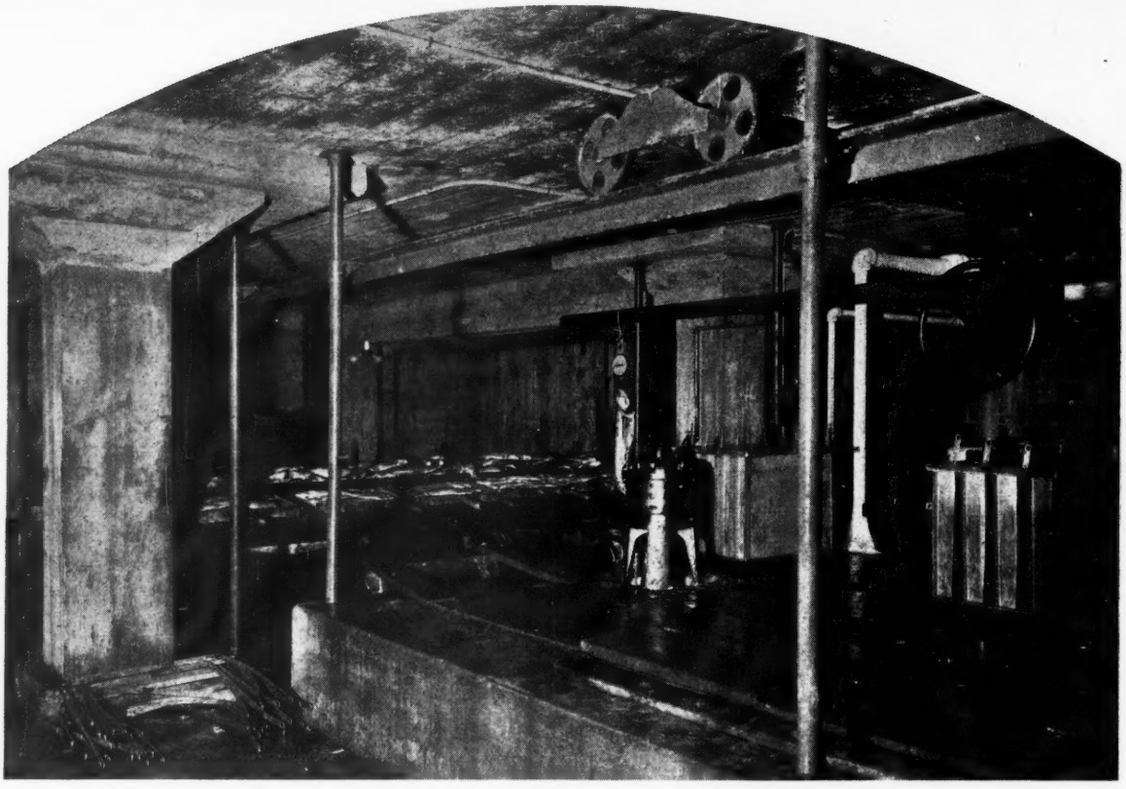
Eleven years ago, Mr. Petersen had scarcely heard of the freezing of foodstuffs. Through personal acquaintanceship in 1919 and 1920 he was drawn into rather close contact with the work being done abroad at the time, and it was not long before a realization of the tremendous possibilities of the whole matter led to him to devote all his energies to it. Purchasing the United States patent rights covering the work of his countryman, A. J. A. Ottesen, as a basis for demonstration and experimentation, he worked on the rapid freezing of meats by direct-immersion methods during 1920 and 1921 in the plants of Armour & Company. Early in 1921, the United States Freezing Company was formed by Mr. Petersen and his associates, to exploit the Ottesen patent covering certain aspects of the rapid freezing of fish. This was intended as a prelude to further work on the freezing of meat, for it appeared that the packers were not ready to consider revamping their entire distribution channels at that time in order to obtain the advantages of freezing.

Six months sufficed for the interested parties to determine that the Ottesen patent did not necessarily prevent deleterious consequences in freezing. As a result, the United States Freezing Company was later dissolved and the Ottesen patent given back to its original Danish owners. But Mr. Petersen continued the work by himself, and before the end of 1921 had evolved an entirely practical method of rapid freezing. Bay City, Mich., was selected by Mr. Petersen and his associates as a logical place to start commercial operations. The Bay City Freezer was built, financed, and put into actual operation in October, 1922, and has been prominent in the freezing of fish ever since.

A number of fundamental patent applications were filed about this time. Basic research upon the problem of processing previous to freezing, still a moot point in discussions of freezing methods, was carried on. As a result of this early work, the first practical system in which compactly packed comestibles were rapidly frozen on a commercial scale between thin walls of metal by means of cold brine flowing in contact with the outside surfaces of the metal walls, a primary concept of practically the whole industry as we know it today, was developed. The process is covered by one of 14 patents which have been issued to Mr. Petersen since 1921. Additional applications are still in the Patent Office at Washington.

Of all the freezing systems now in practical and profitable operation, the Petersen systems are perhaps the simplest, and certainly the least spectacular. There are no elaborate freezing units or intricate plant layouts, the general appearance of the freezing room being very similar to that of the ordinary ice plant. In fact, many of the mechanical improvements and operating economies that have been developed in ice-plant technique are adaptable to the freezing process.

Fish are frozen by the Petersen systems either whole or gutted, with or without the heads removed. As soon as they are received at the plant, the fish are washed in a mild germicide and compactly packed on flat, scoop-



A section of the Petersen installation at the Traverse City (Mich.) Packing Company. The scoops in which fish are placed are shown at the rear. At the right, a rack of cans is shown being lowered into the tank of circulating brine

like pans. The pans usually hold either 20 or 50 pounds of fish. They are of such size that they may be slipped, much like a drawer from which the back had been removed, into a rack holding a number (usually 8) of rectangular metal cans. After a scoop of fish has been slid into each can, the rack is swung through a 90° angle, so that the open ends of the cans are then on top. The scoops are now pulled from the cans, and the fish or other objects to be frozen settle enough by their own weight to press compactly against the sides of the can.

Although the dimensions and divisions of the cans may be varied to suit the size of cake wanted or the type of product frozen, it has never been found necessary to have more than two sizes of can per plant. One popular size produces cakes 2 inches thick, 28 inches long, and 18 inches wide. The freezing, of course, takes place practically wholly across the narrowest dimension. Calcium chloride brine at a temperature of — 25° F. to — 30° F. circulates in the tank into which the racks are lowered by conveyors similar to those used in ice plants. A time of 45 minutes is used in freezing cakes 2 inches thick.

Proper layout provides a continuous freezing cycle, keeping labor charges at a minimum. The advantages of freezing in compact and rectangular shapes are obtained without the necessity of freezing through layers of insulating material. The frozen molds are wrapped and slipped into containers after the freezing operation.

When fish are being frozen, a quick dip of the rack of cans in lukewarm water or brine (often condenser spill water) loosens the cakes, and a swivel-mounted dump turns them out directly into a glazing tank. Dumping the cakes into water in this way eliminates the danger of breaking them apart, as might happen, for instance, were they dumped on the floor.

The cakes of fish emerge from the glazing tank in a room held at a temperature of from 0° to 5° F., where the glaze sets and the cakes of fish are wrapped and boxed. The glaze, as the thin film of ice which coats the cakes is called, as well as the wrapper, prevent any dehydration of the fish in storage. The boxed fish are stored at a temperature of 5° F. Comestibles other than fish are not glazed or dumped in this manner, but are removed from the cans while in the thawing bath by lifting bands frozen into the cans when they are loaded. A number of these lifting bands are shown in the left foreground of the illustration. The ordinary wrapping and packing operations then follow.

The average cost of refrigeration required by these freezing systems, including power, ammonia, overhead on refrigerating machinery and freezing tank, glazing, and storage for a month, total $1.57 per ton of products frozen. When it is undesirable to freeze the comestible in 20- or 50-pound cakes, divisions of paper, cardboard or wood are placed in the scoops. After freezing, the blocks are easily broken apart at these divisions. A process for freezing fish individually in metal containers automatically fitting fish of varying sizes has also been developed. The word "Keenkooled" is a registered trademark protecting the articles produced under the Petersen licenses.

The Petersen systems have been installed on a royalty basis at four plants. The plant at Bay City, Mich., an installation with a capacity of 30 tons a day for freezing fish, and that at Traverse City, Mich., which has a capacity of 20 tons a day for freezing fish and fruit, freeze and store these products as public warehousemen. They will wash, freeze, glaze, wrap, and hold fish in storage for a month for 1.25 cents per pound. A plant with a capacity of 35 tons per day at Winnipeg, Canada, freezes and markets its own fish. For reasons having no connections with the freezing operations, a plant at Detroit, Mich., which has a capacity of 45 tons a day, is temporarily not in operation. Mr. Petersen has no financial interest other than as licensee in any plant except that at Bay City.

The coincidence that all the plants using the Petersen

system are located in districts not producing fish readily filleted is one reason why more effort has not been spent to make the process particularly adapted to freezing fillets. Another reason is Mr. Petersen's conviction that the present vogue for individually frozen and wrapped fillets and steaks is economically unsound. He feels that freezing in larger units, thus saving packaging cost, storage space, and transportation fees, as well as minimizing exposure to the deleterious effects from storage air, has the brighter future.

Any feeling that his process is one of the "early methods" that has just about run its course of usefulness is likely to be forcibly exploded when one talks to Paul Petersen. A man of many interests, he has but recently returned from a year abroad engaged on entirely different matters. He returned, he admits, to find the field "trying to run away with" the business in new developments of frozen foodstuffs.

He is beginning experimental work and re-entering commercial exploitation once more. Improvements and adaptations to make his systems universally applicable are not far off, he contends. A sincere belief in the fundamental economic superiority of his systems, a brilliant mind that sees the many weak spots in the freezing of foods as we know it today, and a dynamic personality that does not seem to trouble a great deal about difficulties of one kind or another, will not easily be sidetracked among the "early investigators."

▼ ▼ ▼

Reactions of Public to Frozen Foods Are Tested

PUBLIC ACCEPTANCE of the wide line of quick-frozen products with which the Frosted Foods Division of General Foods Company is conducting a sales test in Springfield, Mass., at the end of 12 days exceeded all expectations of the most optimistic company executives. Birdseye Frosted Foods, as they are known, were placed on sale on Thursday, March 6, in 10 retail outlets, chosen to give the widest distribution and best cross-section of purchasing characteristics. They are:

Rood & Woodbury, Main St.
Broughton & Fleming, Pine & Central Sts.
Davidson's, Bristol St. & Wilbraham Road
F. W. Jackson, 352 Bay St.
Thrift Store, 140 State St.
Thrift Store, 25 Walnut St.
Thrift Store, 246 Dickinson St.
Thrift Store, 819 State St.
Thrift Store, 719 Summer Ave.
Thrift Store, 10 Bliss Road, Longmeadow

The products on sale embrace 21 cuts of meat, including sirloin, porterhouse, and top-round steaks; veal and pork chops, legs of lamb, rib roast, pot roasts, sausage, stewing beef, and veal. Clerks have reported requests for meat products other than those being sold.

The steaks, chops, sausages, and stewing meats are wrapped in Cellophane, packed in 1- or 2-pound boxes, and these are sealed in waxed glassine paper before freezing. The roasts are wrapped in Cellophane, and are covered with a stockinette bag before being frozen.

The fish being sold in the test consists of 1-pound packages of fillets of sole and haddock, as well as pint boxes of oysters. Fruit and vegetables include cherries, raspberries, loganberries, peas, and spinach, all packed in Cellophane-lined cartons of about 1-pint capacity.

After a day or two of novelty buying, a substantial repeat business developed, and sales showed a consistent increase in all stores. In service stores customers are ordering Birdseye products freely over the telephone.

On favorable shopping days, more than 1,000 customers have purchased the products in the ten stores. Some of the larger stores are selling the products to as many as 200 families per day. After the first three or four days of selling, heavy cuts of meat, including beef, lamb, and pork roasts, moved steadily.

The foods are kept in two types of display refrigerators set to maintain a temperature of 10° F. One type of case is an Oreole, and the other a Frigidaire unit (see page 186). During the week in which this inspection of the trial was made, the temperature was maintained fairly constant, with little frosting of the glass in the display section. This freedom from clouding probably is due to the fact that sales are made from the lower, or storage, part of the cabinet. The storage space of the Oreole case is equipped with drawers accessible through doors, and that of the Frigidaire case is of the bin type, similar to an ice-cream cabinet.

A tour of the stores by a representative of FOOD INDUSTRIES disclosed that each display case was in charge of one or two women who had been trained not only in the sales points but also in the practical preparation and demonstration of the best method of cooking and handling the frozen foods. The latter point is essential, for in cooking a box of peas a minimum quantity of water, well salted, must be boiling when the peas are added. Only 7 minutes is then required to complete the cooking to give maximum flavor, color, and tenderness.

Prices of the frozen foods are being held constant in all 10 stores, and are comparable with those of the best quality of fresh foods. For example, a box of peas was being sold for 31 cents at a time when the retail price for 2 pounds of fresh unpodded peas, equivalent to the box of frozen product in quantity, was about 38 cents. When waste from whole or unfilleted fish is taken into account, the price approximates the 29 cents charged for a pound box of haddock fillets in Springfield. The frozen sirloin steak at 89 cents per pound compares favorably with an equal grade of fresh meat as cut and trimmed by the local butcher. Complaints concerning quality have been negligible, and when reported, were found to be due to improper cooking in nearly every case.

The thorough manner in which the test was carried out, in its educational aspects as well as in the diversification of distributing channels, and the quality of the products, only serve to emphasize the magnitude of the problem of securing general acceptance of quick-frozen foods.

Although important grocery stores in nearby towns, in response to suggestions of customers who have been buying the Birdseye products in Springfield, have asked for low-temperature display cases and stocks of the new products, it must be remembered that the test is one of consumer acceptance and not of economic justification of the entire cause of frozen-food distribution.

CANADA EXPERIMENTS

With "Ice Fillets"

By R. A. McKENZIE
Biological Board of Canada
and
J. W. R. HARKNESS
University of Toronto

ACTUAL test of its effectiveness by commercial sales has proved to the satisfaction of the Canadian government that the new process of "icing" fish for inland sale, as developed by the Biological Board of Canada, is soon to become the generally accepted method of treating and handling these products.

It was because Canadians, with excellent fisheries on both seaboards, include in their diet a relatively small proportion of fish, thus depriving themselves of a particularly healthful food and at the same time discouraging a valuable industry, that the Biological Board of Canada—the research branch of the department of marine and fisheries at Ottawa—was set the task of finding the best means of delivering the product of these fisheries to the inland portions of the country in the best possible condition. As a result there was developed at the stations at St. Andrews, N. B., and Halifax, N. S., during the winter of 1927-28 a frozen product to which has been given the trade name of Ice Fillets. It is believed that the new product will serve to demonstrate the fallacious nature of the old idea that all frozen fish is inferior fish.

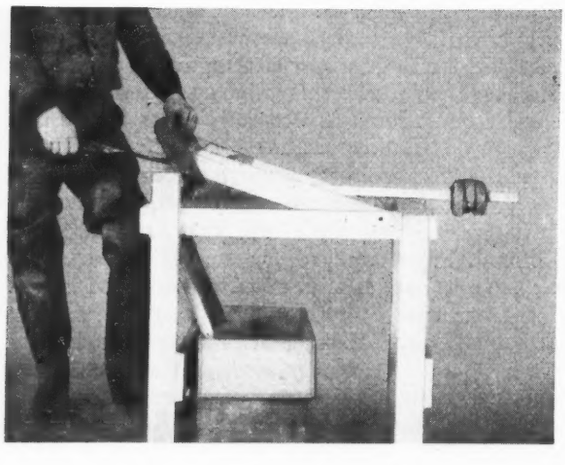
By virtue of this method of processing and handling marine products, lovers of sea food in inland Canada should soon be able to obtain all kinds of fish in their original, sea-fresh condition. One who has eaten freshly caught pickerel in northern Ontario asserts that Ice Fillets of flounder have a finer flavor. Another, who has eaten St. John Harbor salmon and the shad of the same place, haddock at Annapolis, mackerel at Halifax, and fresh cod in Cape Breton within 4 hours after the fish were caught, declares that none of these is superior to the rapidly frozen ice fillets of fish which are cleaned, prepared, frozen, and packed as expeditiously as possible after they are taken from the sea.

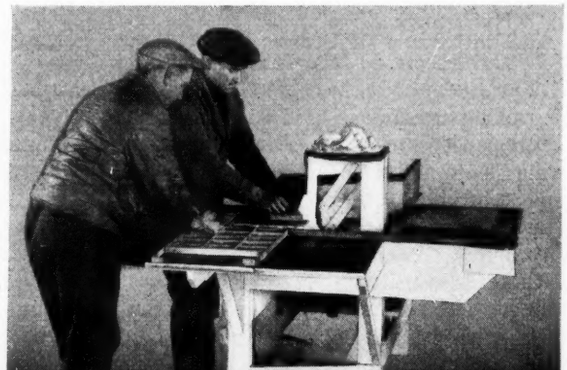
In the face of the admittedly widespread prejudice against the use of frozen fish it may seem radical to insist that the consumer receive in that condition fish intended for the table, and yet that is just what is now being advocated. But the frozen fish of today is of very different quality from that of some years ago. Much of the frozen fish of the past did not deserve any better reputation than it bore, and chiefly for the twofold reason inherent in a stale material slowly frozen.

Science has not yet discovered a method by which fish stale to the point of partial decomposition may be brought back to their original state of freshness. Certainly brine freezing will not make the product better than the fish are at the beginning of the process. But it will make it possible for the consumer to get fish as fresh as they are when landed. Also, for many years it has been known that if flesh of any kind be slowly frozen the tissues are damaged inevitably, and this becomes apparent only when the flesh is thawed. The chief effects are that the fibers are toughened; the tissue juices, carrying with them the flavor, immediately leave the flesh; and subsequent deterioration is rapid. If, on the other hand, the tissue—in this case the fish—be frozen with sufficient rapidity, none of these harmful results ensues. The tissue, when thawed, returns to its original condition; it is not toughened; the juices do not escape; and the flavor is retained.

In the manufacture of Ice Fillets the following steps are taken: When the fish are taken from the sea they are immediately cleaned, washed, and then iced in the hold, whether in a schooner or trawler. Improvements

Fillet skinner in operation





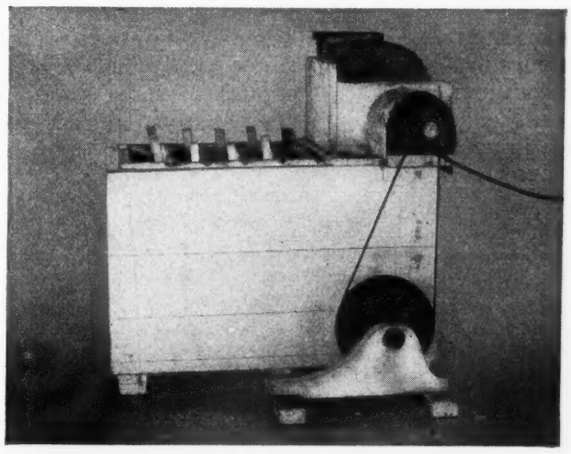
Hand filleting machine; also showing packing of ice fillets for freezing

in the methods used for icing the fish on the vessels during transportation to port have been devised and further betterments are expected. Boats operating near the shore make comparatively short trips.

As soon as the vessel reaches shore the fish are taken to the plant for processing. Fish that cannot be butchered and frozen at once are placed in a bath of water slightly less salty than sea water. By circulating this dilute brine through ice it is cooled to between 30° and 31° F., a temperature impossible of attainment by ordinary icing were it not for the solid matter dissolved in the brine. By this means it is possible to keep the fish at a temperature slightly above their freezing point. Even so slight a temperature differential as is involved here has been found to assist materially in slowing up the changes involved in spoiling.

As rapidly as possible the fish are taken from this bath and the fillets cut from their sides in such fashion that all bones are left behind. Next the skin is removed, leaving nothing but fresh fish muscle.

The fillets are cut transversely into pieces 5 inches long, and are fed into a mold 5 inches long, 3 inches wide and 1 inch deep, which when filled holds ½ pound. As



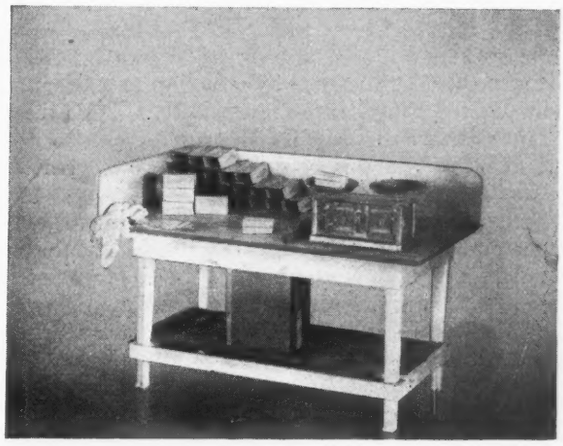
Ice and salt freezer for fillets

they come from the mold they are wrapped in a sheet of waxed vegetable parchment and placed in metal frames of the proper size to receive them. The blocks of fish in the frames are slipped into metal envelopes and immersed in a circulating brine the temperature of which is 0° F. or lower. The salty brine does not touch the fish, but is in the closest contact with it through the metal covering. Freezing is accomplished in a period of from 15 to 20 minutes. On removing the frame from the pan, it is found to be filled with full frozen cakes of fish. Two of these cakes are slipped into a waxed carton, and the product is ready for storage or sale.

The product is strictly fresh; without waste material, such as bone and skin; of uniform thickness and of size and shape suitable for cooking by frying or otherwise, and of standard, ½-pound weight, rendering weighing unnecessary; frozen rapidly (in less than 25 minutes), thereby avoiding damage through the formation of large crystals, such as are formed when flesh is frozen slowly; wrapped and packaged in sanitary fashion, by the use of waxed parchment paper and cartons.

If Ice Fillets are to be stored, every effort must be made to keep the fish frozen. Once the fillets have been rapidly reduced to 0° F., they are protected against any appreciable deterioration, and so long as their temperature is not allowed to rise above 10° F., their pristine condition is maintained for some time. When storing Ice Fillets for shorter periods, or immediately preceding consumption, higher maximum temperatures may be used.

Because of the temperature at which they are frozen and the method of packing, the fillets may be transported for long distances in a condition which approximates, as closely as science renders possible, their



Packing and weighing table

condition when taken from the sea. Shipments to Toronto from the Atlantic coast have been made—with and without insulation—by ordinary express, by refrigerator express, and by fast freight. Further experiments in shipping will be made during different seasons of the year.

When the Ice Fillets were ready for marketing, the advisory committee of the Biological Board recommended that an attempt be made to market them in Toronto, as it was thought that Toronto offered perhaps the best conditions for the experiment, being far enough west to furnish a good test of the transportation difficulties, and not so far west as to be out of the Atlantic fresh-fish zone. It seemed desirable that this product be compared as to salability with unfrozen Atlantic fish.

In the spring of 1928 samples of Ice Fillets of haddock that were distributed to the wholesale and retail trade in Montreal, Ottawa, and Toronto received favorable comments. An advisory committee on marketing, consisting of representatives of the wholesale and retail trade, was then formed in Toronto to serve in connection with the marketing experiment.

By early January, 1929, a stock of about 2 tons of Ice Fillets of haddock had been accumulated, and a weekly production of upward of 1,000 pounds was under way and ready for shipment at the Board's two Atlantic stations, at Halifax and St. Andrews. Since then other varieties—halibut, cod, hake, plaice, flounder, Restigouche salmon, swordfish, and mackerel—have been put up in the form of Ice Fillets, and two commercial firms situated at Lockeport, N. S., and Lunenburg, N. S., are putting up Ice Fillets under the supervision of the Biological Board of Canada. Small herring, headless and dressed, also have been packed in the same frame and frozen rapidly. Of course, these have *not* been sold as Ice Fillets.

Then, too, in order to have a product that will more nearly meet the needs of restaurants and hotels, changes have been made in the size of the cakes and methods of packing. In addition to the ½-pound cake in its indi-

vidual carton, there have been produced cakes weighing 3 to a pound; packed loosely in 12-pound boxes.

Upon reaching their destination—Toronto, for example—shipments are transferred from the railway car as rapidly as possible to wholesale warehouses, where they are kept in freezers at a low temperature. Retailers handling these fillets should be equipped to keep them in a solidly frozen state. This product cannot be marketed properly in the way in which fish have formerly been handled, but modern electrical ice cream cabinets serve the purpose very well. In Halifax, exceptional enterprise and initiative are being shown by the local firms in perfecting methods by which the housewife may be handed Ice Fillets in a frozen state. These methods bid fair to show the way for the rest of Canada to follow. However, in this connection, there is great scope for further experimental work.

The housewife can place them in the pan without any further preparation, other than the removal of the wrapper. Although they will remain perfectly fresh for some hours after thawing, for full freshness and flavor Ice Fillets should be cooked while still frozen. Searing the surface while still solid retains all the juices. Their freshness is shown not only by their original sea flavor, but by their firmness and by the absence of any strong or fishy odor. They might be cooked in the drawing room without offense. Miss Dorothy Dow, Department of Household Science, University of Toronto, working in conjunction with the Atlantic Biological Station, has tried out and recommended numerous recipes for the cooking of Ice Fillets.

From the first this product was put on the market through the regular fish trade channels. Here it had to compete with recognized kinds, processes, and brands. In addition, there has been a certain amount of controversy among various dealers, one reason being that it would require a considerable outlay for proper equipment if a demand for this article were created. However, the new product has been tried and found excellent by retail stores, hospitals, restaurants, industrial cafeterias, and fish and chip dealers. In fact, some dealers now are handling this line of fish only. In the future, no doubt, many other lines of solidly frozen material will be handled in conjunction with this product.

Of the three main operations in the production of Ice Fillets, the process of making the cakes and wrapping them in waxed paper is perhaps the one that will slow up the production most. A machine for performing this operation has been designed and built by Dr. A. G. Huntsman, director of the Atlantic Biological Station, at St. Andrews, N. B., in conjunction with a company making automatic machinery. Also, a new machine for freezing the cakes will be completed in the near future.

By the introduction of machinery, production can be increased to supply any demand. However, in order to make this new scientific product a common household commodity, it should be taken up by Dominion-wide organizations that will make it a special line. Marketing methods such as are used by many of the present-day ice cream companies should prove adequate, when linked with firms on the coasts that are properly equipped to produce Ice Fillets.

ICE CREAM

Improved by Quick-Freezing

By C. D. DAHLE
Professor of Dairy Manufactures, Pennsylvania State College

THOSE who have been in the ice cream industry for the last 10 or 15 years easily recall the time when textbooks and college professors and convention speakers taught that ice cream should be frozen with a brine temperature of 10° to 15° F., and that it should take from 12 to 15 minutes to turn out a batch of ice cream. True enough, some still believe in the efficacy of those methods; some, indeed, find conditions similar to these in their own plants today, but not so often from choice as because of inadequate refrigeration facilities or obsolete equipment. We used to say that a hardening room should not be permitted to go above 10° F. Now, a temperature of 0° F. is considered too high. Freezing mediums of —10° to —15° F. are the rule rather than the exception in many plants today.

The question as to what has brought about the change in these conditions is easily answered. Of prime importance is the fact that ice cream mixes contain more solids than before, particularly serum solids and sugar. This requires lower temperatures to cause the mix to freeze in a given time. Secondarily, it has been demonstrated that the capacity of the plant has been stepped up considerably by using a colder freezing medium. Less time therefore is spent in the freezing operation. More ice cream can be made per day.

Another important result of using a colder freezing medium, but which is the last one to be recognized, is the improvement in texture of ice cream. Just why this occurs is realized readily when one considers what takes place during the freezing process.

During the freezing process the refrigerant is extracting heat from the mixture, reducing the temperature until a point is reached where some ice crystals form. Meanwhile, some air is being whipped into the mix,

which is becoming increasingly stiffer until a point of stiffness is obtained wherein it is considered desirable to shut off the refrigerant to prevent the ice cream from becoming too stiff. The remainder of the freezing process is then spent in producing the desired volume by whipping air into the ice cream.

If the temperature of the freezing medium is high, the time spent in reaching the point where it is desirable to shut off the freezing medium may be comparatively long. Therefore the ice crystals that are forming will be larger than if the crystal formed quickly, because of a colder freezing medium, for it is a well-known fact that a quickly formed crystal is a smaller crystal than one slowly formed. During the whipping period, after the freezing medium is shut off, there may be some melting of the previously formed ice crystal. This is not only wasteful of refrigeration but also detrimental to texture, as more ice will then be required to be formed in the hardening room, a slower freezing process. Because the ice crystals are formed more slowly in the hardening room, they will be larger.

When a colder refrigerant is used the heat is extracted more quickly, ice crystals form more quickly, and consequently are smaller, the refrigerant is shut off sooner, and the overrun is obtained more quickly. The temperature at which the ice cream is drawn from the freezer is lower, and the previously formed ice crystals have not had an opportunity to become melted. Thus, there will be necessary the formation of less ice in the hardening room, with a resultant improvement in the texture of the ice cream.

C. D. DAHLE

In freezing ice cream nowadays the rule is to freeze the mix as stiffly as possible in the freezer without sacrificing time and overrun. By freezing the mix stiffer in the freezer it is possible to freeze more water, or form a greater number of ice crystals in the mix, before hardening. The more water so incorporated in the frozen mix and the shorter the time requisite therefor, the better will be the texture of the finished ice cream. It may then be expected that a smoother product will result if the freezing is done in relatively few seconds as compared with several minutes.

A freezer has been developed recently that accomplishes very quick freezing, the mix passing through the freezer in the course of a few seconds.

During the passage of the mix through the freezer the necessary air is incorporated and a certain amount of water is frozen. When this ice cream is later hardened and compared with ice cream from the same mix frozen in the usual type of freezer, a striking difference in texture is evident. Ice cream frozen in the freezer in the shortest time has much the better texture. This may be attributed to two sources, the rate of freezing already mentioned and the quantity of ice frozen in the freezer. Because the temperature of the ice cream from the faster freezer when so handled is usually lower than that of the same ice cream frozen in the average freezer, the quantity of water frozen before hardening will be greater. There will then be less water to be frozen in the hardening room.

Hall[1] stated that approximately 30 per cent of the water of the ice cream mix is frozen in the freezer during the freezing process, and possibly not more than 70 per cent of the water is ever frozen even after hardening. The importance of freezing the maximum quantity of the water in the freezer, leaving the minimum to be frozen in the hardening room, can be seen. Also, the importance of hardening as quickly as possible can be appreciated. In many plants this fact is too often overlooked. It is not uncommon to find the core of a 5-gallon can of ice cream still soft after 36 hours in the hardening room.

One of the reasons for the failure of popularizing packaged cream is the lack of knowledge of the importance of quick freezing, and particularly quick hardening. Many concerns go to no end of trouble to make a splendid mix, prepare elaborate cartons, freeze properly, fill the package with automatic fillers, and the like—all without bearing in mind one of the most important steps of the whole procedure of making packaged ice cream. Often these concerns run the ice cream into cartons that are at the temperature of the room, the carton is passed along on a table and together with 8 or 10 or more other cartons, placed in a paper bag and sealed. This bag of packages may then be placed on a truck and, when the truck is filled, hauled into the hardening room, there to be stacked on shelves for assembly with other packages. Before the hardening room is reached, several minutes have elapsed and the ice cream around the edges has begun to melt. The ice cream inside the bundle or package is insulated by three or more thicknesses of the heavy paper of the cartons and will be hardened very slowly. Consequently, the texture of the packaged ice cream is greatly impaired. As a matter of fact, packaged ice cream should have better texture than bulk ice cream (in a 5-gallon can), because the smallness of the package offers greater possibilities for relatively quick hardening.

Whenever ice cream is stacked in great quantities in a hardening room it is obvious that the texture will suffer, the refrigerant not having equal access to all parts of the container. Hardening should be accomplished as soon as it is possible to do it. All that is necessary to prove the importance of quick hardening is to freeze a small block of ice cream from the freezer with solid carbon dioxide and compare it with a sample of the same ice cream hardened in customary fashion.

So important has the packaged ice cream industry become in some cities that methods of producing the most nearly ideal package of ice cream have been given considerable study. The great success of the quick freezing of fish and other products has given ice cream manufacturers a valuable hint in answering one of the big questions of quality of packaged ice cream; and *all* ice cream, for that matter. Production men in ice cream plants have been experimenting with methods and processes for accomplishing the quick hardening of ice cream as soon as it comes from the freezer. The present year, no doubt, will witness the installation of systems in ice cream plants for accomplishing the hardening of ice cream in an hour's time, more or less. The problem involved in adopting a method of hardening quickly is to provide a system that will not require too much labor, space, or refrigeration to permit its economical operation.

[1]Hall, Thomas, *Ice Cream Trade Journal*, XVII, No. 11, p. 71, 1921.

REFRIGERATION

In Connection With Frozen Berries

By C. T. BAKER
Consulting Engineer
Atlanta, Ga.

AT PRESENT an entirely new phase of the application of refrigeration to perishable commodities is well started; in fact, great progress has already been made in this comparatively virgin field. Refrigeration now makes it possible to conserve and to market certain commodities that must, under normal conditions of distribution, be consumed in a comparatively short time or go to waste. In Alabama, for example, it often is impossible to find a profitable market for all of the relatively large crop customarily produced by strawberry growers in that state, with a resultant financial loss of considerable magnitude to the producers.

Plans are now being considered for the establishment of suitable quick-freezing plants which will enable the growers to eliminate or minimize these losses. At Macon, Ga., considerable experimental work was done a few years ago—but on a comparatively small scale—to determine how best to freeze strawberries in order to make them available for consumption during out-of-season periods.

In this plant, which had not been designed originally for strawberry freezing, the berries were hulled and sorted and placed in tin cans of 3 and 5 gallons capacity, then frozen at temperatures ranging from 5° F. to 0° F. When packing the berries in the cans it was, of course, necessary to allow ample space for expansion of the mass as freezing progressed. After being packed, and before going to the freezer room, each can was supplied with a tight fitting lid, hermetically sealed by means of a soldered joint. In connection with placing the cans in the rooms for quick freezing it is highly desirable that ample space be provided between the containers to permit free air circulation. Otherwise, cooling will be slow and there will be danger of fermentation and spoilage due to the fact that the fruit in the center of the can gives up heat slowly, because of the insulating effect of the outer frozen mass, which retards the rate of heat transfer from the center outward.

The rate of cooling may be accelerated greatly by the use of forced air circulation. When so employed, the air is reduced in temperature by passage over the cooling coils, then delivered at high velocity to the containers.

One of the early discoveries in the freezing of berries was that quick cooling is essential if the rate of respiration is to be held within safe bounds. Also, yeasts and molds in berries develop relatively rapidly at temperatures above 45° F., which results in spoilage. At the Macon plant, the berries were held after complete freezing at about the same temperature that was maintained during the freezing period. However, frozen berries may be stored safely at 18° to 20° F., their normal carrying temperatures.

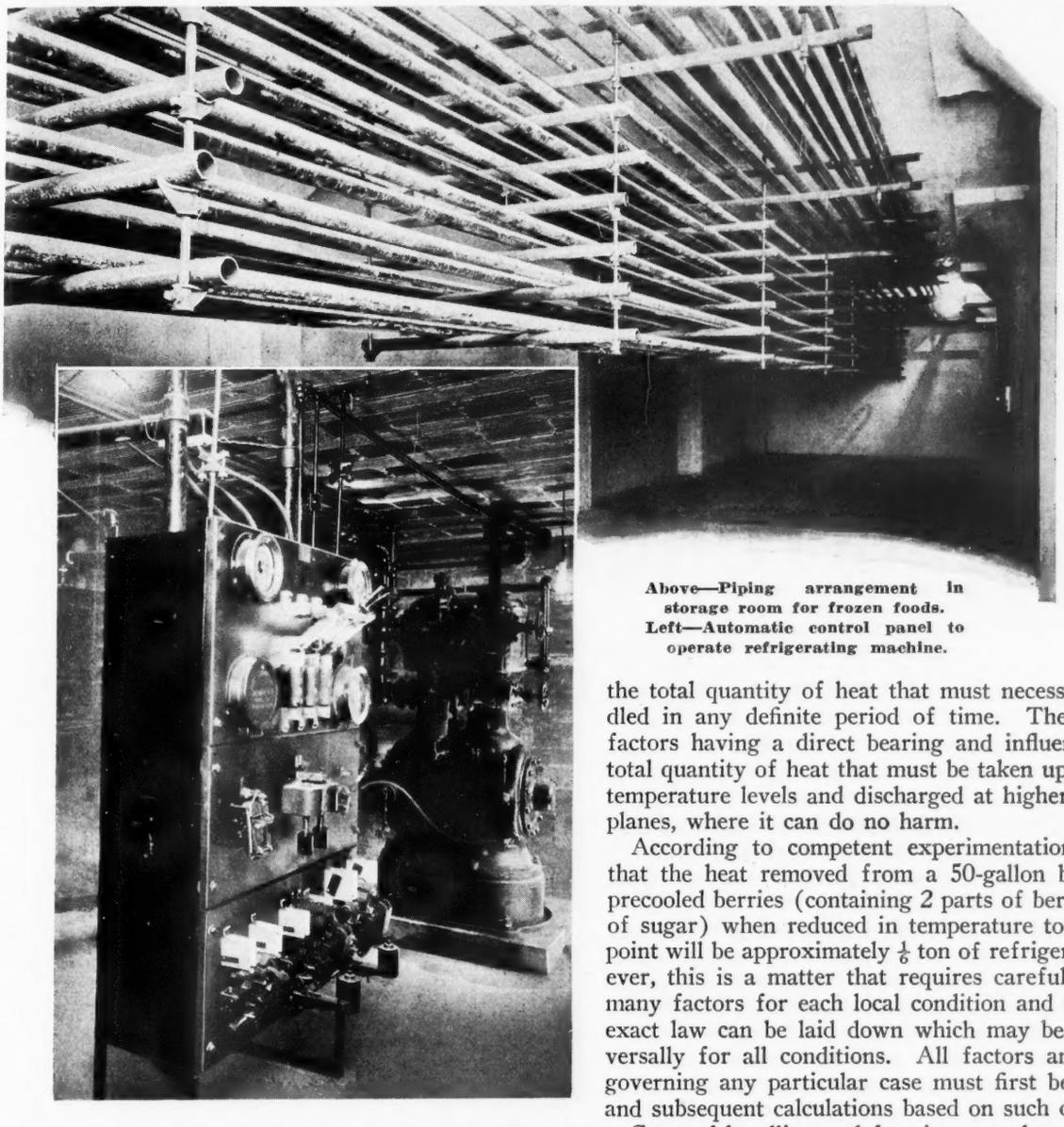
No particular type of refrigerating equipment is required for this sort of freezing. The usual ammonia compression machine is employed in connection with well insulated freezer rooms that are so arranged as to facilitate handling of the particular commodity to be frozen. Because the temperatures to be carried are considerably lower than obtain in the ordinary cold-storage plant, it is necessary that ample insulation be provided, in order to retard heat leakage from the outside air to the freezer rooms. Also, when designing equipment for this class of service it is of importance that those engaged be competent to evaluate the refrigerating requirements for any given case. There always are a number of factors to be considered. The principal determinant, of course, is the total amount of heat that must be extracted from the commodity for each unit of time, which in turn determines the size, or capacity, of the refrigerating machinery.

The necessity of proper insulation is twofold: first, heat leakage from the outside must be held within limits, otherwise the refrigerating cost of maintaining safe temperatures will be excessive and the installation cost of equipment will be abnormal, because of the large capacity required to meet the refrigerating demands and, second, when rooms are improperly insulated there always is danger of spoilage, which comes with temperatures that are not maintained sufficiently low.

For room temperatures of 10° F. to 0° F. or —10° F., not less than 8 inches of pure sheet cork or its equivalent should be used. In addition, insulation should be applied in keeping with the best known practice, otherwise trouble will result from both abnormal heat leakage and rapid deterioration.

Of equal importance in the construction of freezer rooms are the cooling coils, which to be effective must be located with proper reference to spacing, wall or ceiling, as the case may be, and so arranged as to insure circulation of both the relatively warm and the refrigerated air. Coils supported from the ceiling must be provided with suitable watertight collectors or "under-pans," to prevent drippage of water when accumulations of frost are thawed, an operation that is necessary at intervals during the storage period. Insulation and cooling are of particular importance in freezer operation because the success of any frozen-food development will depend primarily upon correct and constant temperatures.

Although it adds slightly to the cost of construction, the provision of facilities for pre-cooling the berries before packing in barrels or other containers generally proves to be a good investment. By this means, when the correct temperature is maintained, the natural heat is removed rapidly, because intimate exposure of the material to refrigerated air is possible. Thus, the fruit is cooled quickly to a temperature at which the respira-



Above—Piping arrangement in storage room for frozen foods. Left—Automatic control panel to operate refrigerating machine.

tory rate is lessened materially, as is the possibility of mold growth.

When berries are washed in connection with the operations of sorting and hulling, often an excess of moisture is carried into the pack. Pre-cooling before packing may be used to advantage in dehydrating to a certain extent berries thus laden with moisture.

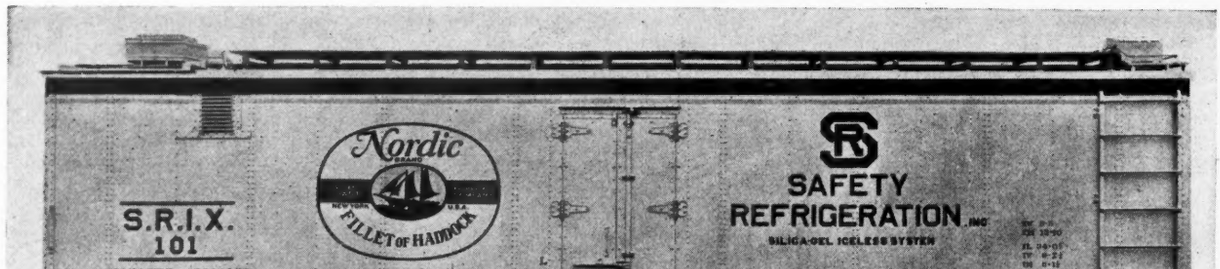
When calculating the amount of refrigeration necessary to freeze strawberries in this manner and to maintain proper storage temperatures, the factors that must be evaluated carefully include: heat leakage into freezer rooms, because of differences in temperature between the inside and outside air; weight of berries to be frozen; initial and final temperature of the berries; weight of containers and initial temperature thereof; quantity of sugar used, if any; specific heat of the foodstuff above and below the freezing point; latent heat of freezing.

There is also to be considered the matter of the heat generated and given off by respiration, which is, of course, more pronounced at the higher temperature levels. However, as cooling progresses from initial to freezing temperatures the rate of heat so generated diminishes. Obviously, by no means available will it be always possible to predetermine with absolute accuracy the total quantity of heat that must necessarily be handled in any definite period of time. There are many factors having a direct bearing and influence upon the total quantity of heat that must be taken up at the lower temperature levels and discharged at higher temperature planes, where it can do no harm.

According to competent experimentation, it appears that the heat removed from a 50-gallon barrel of unprecooled berries (containing 2 parts of berries to 1 part of sugar) when reduced in temperature to the freezing point will be approximately $\frac{1}{6}$ ton of refrigeration. However, this is a matter that requires careful checking of many factors for each local condition and no absolutely exact law can be laid down which may be applied universally for all conditions. All factors and conditions governing any particular case must first be enumerated and subsequent calculations based on such data.

Costs of handling and freezing strawberries and other products, as well as those of buildings and equipment, depend upon local conditions to such an extent that they can be ascertained only by careful survey of any given locality, with special reference to existing conditions, the labor and power market, and other governing factors. Modern, automatic refrigerating machinery is available that will meet easily the most exacting temperature requirements with consequent simplification of most problems of refrigeration.

Many existent ice and cold-storage plants, if altered slightly, could qualify for entry into the field of frozen products, and in so doing increase their revenue materially. There is absolutely no question that this branch of the refrigerating industry is going to be developed rapidly, and that it will have broad application in the food industries. Certainly the present indications are that a great variety of fruits and vegetables can be so handled, and much more satisfactorily than by the methods that have been long in vogue. When discussing this topic, it should be borne in mind that refrigeration provides the means not only of preserving the foodstuff in a frozen condition but also preserves the natural flavor and other properties demanded by the consumer.



TEMPERATURE CONTROL

In Railway Transportation

By HORACE M. WIGNEY
Manager, Safety Refrigeration, Inc., New York City

ACCURATE REGULATION and economical maintenance of low temperatures during the railway transportation of perishables have long been desired, and the increase in the volume of foodstuffs distributed in a frozen condition makes this accuracy and economy more essential every day. The disadvantages of the ordinary iced refrigerator car for shipping material that not only must be kept at a specific temperature well below freezing, but that is open to serious deterioration if there be any variations in temperature even below the freezing point, are too obvious to mention. Of the 20,000,000 pounds of perishables valued at $7,500,000 that have been shipped in the Safety automatic iceless refrigerator and heater cars during the past 18 months, frozen foods, especially frozen fish fillets, have occupied a considerable place.

The necessity for invariable temperatures within the refrigerator, whether the outside temperature be above, equal to, or below it; whether the goods be in transit or on a siding; whether it be the beginning or end of the journey, is an absolute necessity in the shipment of frozen foods unless the cost and space requirements of heavy insulation are to be encountered. Any feeling, however, that the difficult conditions and rigid control necessary in shipping frozen foods without heavily insulated containers make this car an expensive requirement—a sort of "necessary evil"—certainly can not be substantiated. True, it does give rigid control at low temperatures, but even in the ordinary cold storage field it can justify itself on an economic basis for the transportation of quality products.

Shipment of Pears Shows Value

Let us consider an example: On Feb. 20, 1930, one of the new all-steel iceless refrigerator and heater cars was loaded at Yakima, Wash., with 756 boxes of pears from cold storage. These pears were placed in the car at a temperature of 31° F. The air temperature of the car was 32° at the time of loading, as the thermostat was set to maintain that degree of temperature throughout the trip. The outside temperature en route ranged from about 50° F. during the first part of the journey to about 6° after the car had been on its way a few days. The shipment arrived in Jersey City on Sunday morning, March 2, but was not unloaded and placed at auction until Wednesday morning, March 5, and an average temperature of 32° was maintained in both the fruit and the car from the time the shipment was loaded in Yakima, on Feb. 20, until it was unloaded, March 5, including the two days it was held on track in the Jersey City yard.

Both the heating and refrigerating apparatus operated automatically en route, supplying either refrigeration or heat as required to hold the temperature evenly at 32°. This car carried and perfectly refrigerated 756 boxes of pears, by reason of its overhead method of refrigeration, as against the average load of 511 boxes in the ice-bunker refrigerator, the height of the load in the ice-bunker car being limited by reason of end ice-box method of refrigeration. The lading, therefore, was increased 245 boxes, or 48 per cent, over the ice-bunker type car.

The fruit which arrived in the car, when placed at auction on March 5, brought 40 to 50 cents more per box than was received for fruit from the same district in other refrigerators of the ice-bunker type. This amounted to more than $300 on the carload. This test was made under the direction of the U. S. Department of Agriculture, and was in charge of E. D. Mallison,

marketing specialist of the Bureau of Plant Industry, and C. L. Powell, junior physiologist of the U. S. Department of Agriculture, who took temperature readings several times daily.

Advantages of the Car

The operating economies of the adsorption system of refrigeration are especially pronounced in a motive installation, because the necessary energy for operation of the circuit can be supplied directly by gas heat from tanks located under the car. In a mechanical system driven directly or indirectly from the power supplied by the engine, the fundamental inefficiency of the locomotive in changing heat energy to mechanical energy cannot be overlooked. Moreover, in addition to high power requirements, the necessity for supplementary means of operation when the car is not in motion, if accurate temperature control is to be maintained, must be met even at the most out-of-the-way point.

Contrasted with the iced car, the advantage of accurate temperature control, of course, is the most important. In addition, the relative compactness of the silica-gel apparatus increases lading space. The absorber occupies a space equivalent to that occupied by one ice-bunker at one end of the car. As the evaporator is placed above the lading and spreads the entire length of the car, cooling is not dependent on the longitudinal circulation of the air, and the height of the load may thus be materially increased. This overhead arrangement of the evaporator also makes it possible to increase the length of cars without affecting the uniformity of temperature.

The fuel tanks have storage capacity for sufficient fuel to maintain operation for 7 or 8 days under normal conditions, which saves the carriers a considerable amount in switching and labor necessary in the case of iced refrigerator cars which are handled to and from icing stations for re-icing about once every 24 hours. The brine which drips constantly from cars using ice and salt as a refrigerant, causes very heavy damage to railroad property, such as rails, switches, signals, bridges, and the like. The iceless refrigerator car entirely eliminates this great expense to the carriers.

The apparatus consists essentially of three parts: the adsorber (containing the silica gel), evaporator, and condenser. It may be briefly described as being identical to a compressor-type machine, in which the compressor has been replaced by the adsorber; the adsorption of the refrigerant vapor by the silica gel corresponding to the suction stroke of the compressor and the activation of the silica gel to the discharge stroke.

The evaporator consists of a series of parallel pipes, running longitudinally in the car and connected to a transverse header, and contains liquid sulphur dioxide. It is suspended close to the ceiling of the car. Below these pipes hang a series of small troughs arranged to catch and carry off condensation from the pipes, thus keeping the lading dry. The condenser is of the air-cooled type and consists of a series of pipes mounted on the roof of the car and protected from the direct rays of the sun by a covering, which at the same time permits free circulation of air over the condenser.

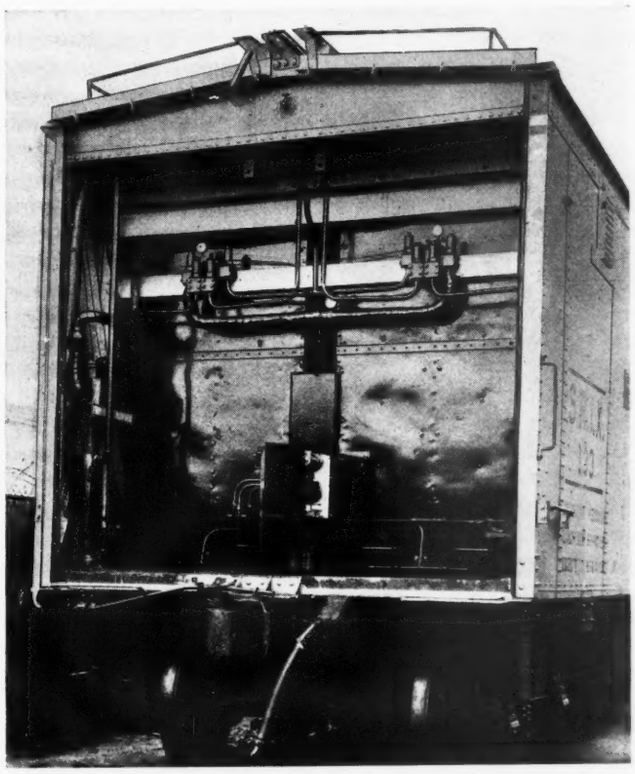
The two sections of the adsorber are placed at one end of the car and outside the insulated car body. The groups of vertical tubes containing the silica gel are placed in insulated fireproof casings provided at the top with ventilators to give a rapid upward movement of air or products of combustion from the gas burners. The burners which furnish the heat for activating the silica gel are placed below the tubes. The float valve is mounted in front of the adsorber and the two manifolds containing the check valves are just above the float valve. Fuel used for heating is carried in tanks suspended under the car body, and is fed to the burners at reduced pressure through a pressure regulator.

Car Temperature Controlled by Thermostats

The temperature within the car is controlled by two thermostats, one with its temperature-responsive element (bulb) mounted near the ceiling at the center of the car. The other has its bulb so located that it is affected only by atmospheric temperatures.

If the lading is such that it requires combination heater and refrigerator service, the heater may be placed in operation and both thermostats set for the desired carrying temperature. Under these conditions, the control will permit the refrigerating apparatus to function only if the car temperature is above the desired temperature. The control is so arranged that if the outside and car temperature falls 5° or more below that at which the thermostats are set, the heater will automatically operate. The control is so arranged that both heating and refrigerating systems cannot be in simultaneous operation.

Open end of silica-gel refrigerator car showing arrangement



GLASS CONTAINERS

For Frozen Fruit Products

By P. R. NELSON and C. W. LANG
Glass Container Association
New York City

THE TREND of the frozen fruit industry appears to be moving rapidly toward the small container which will reach the ultimate consumer. Certain fruits are susceptible to air discoloration even when frozen, and such fruits should be packed only in air-tight containers or, better still, under vacuum. By packing fruits in a sirup which will protect the surface of the fruits from the air, it has been found that the tendency toward surface discoloration is lessened. Some products, however, are not effectively preserved by the use of sirups alone and require vacuumization as well.

Because of the ease of vacuumization with glass containers, the Glass Container Association has conducted some preliminary experiments on the heat transfer in glass, and associated problems. It is probably only natural that the question of breakage should come to mind, because of the expansion of water on freezing. Breakage of glass from temperature shock, however, should not be expected, because, unless freezing is accomplished at such extremely low temperatures as —30° to —40° F., the difference between filling temperature and freezing temperature is not greater than that recognized as permissible when hot liquids are introduced into containers at room temperature. The consensus of opinion appears to be that 0° to 10° F. is satisfactory for the freezing of fruit and vegetable products, and consequently the question of breakage on these grounds should not be expected.

A straight-sided container or one with only a slight shoulder should probably be recommended for freezing, because in containers of these designs, there would be less danger of abnormal internal pressures developing after freezing begins. In a container with a wide shoulder it is conceivable that, after the product becomes too viscous to flow, expansion at the shoulder would cause breakage.

It is the opinion of the laboratory that the closure for frozen fruits should be the type that is held in place by vacuum or will vent if the internal pressure becomes too great because of too high a filling level. It must be realized that the question of filling levels in containers of frozen products is just as important as for products that are to receive heat treatment. An additional value of this type of closure is that venting would occur if gaseous spoilage resulted through improper handling before the product was opened by the consumer. It is not necessary to discuss the dangers from extremely high pressures due to fermentation.

The preliminary work of the laboratory was made possible through the courtesy of the horticultural manufactures and pomology departments of the Massachusetts Agricultural College, which furnished several varieties of frozen fruits for heat-transfer measurements and the use of the cold room for freezing.

The temperature of the cold room was maintained at 10° F. Heat-transfer measurements were made by means of thermocouples[1] in the centers of the containers. Cold junctions were maintained in the cold room in an air bath to protect them from any slight fluctuations in temperature.

The only fresh fruit available was strawberries and these were packed in sirups of 50° and 60° densities. Diehl[2] has reported that a sirup is to be recommended for the small package rather than sugar as its aids in preventing surface discoloration. A 50° sirup seems to be the minimum concentration necessary for good color retention, so that these concentrations probably would be within the range of commercial practice. Two 8-ounce jars were packed with berries and filled to the shoulder of the container with a 50° sirup, and an 8-ounce and 4-ounce jar with a 60° sirup. The 8-ounce containers were jars with a slight shoulder and the 4-ounce was a jelly jar.

Freezing was conducted with the containers stacked in such fashion as to insure free circulation of air so that heat transfer would not be retarded.

The berries cooled quickly (Fig. 1) and, after passing through a supercooled condition, froze rapidly with the temperature falling close to cold-room temperature in less than 24 hours. The larger containers with 60° sirup, however, had not frozen and crystallization had formed only in the upper half of the container. In the 8-ounce container the freezing seemed to begin at the top, and the crystals grew downward through the liquid, so that a

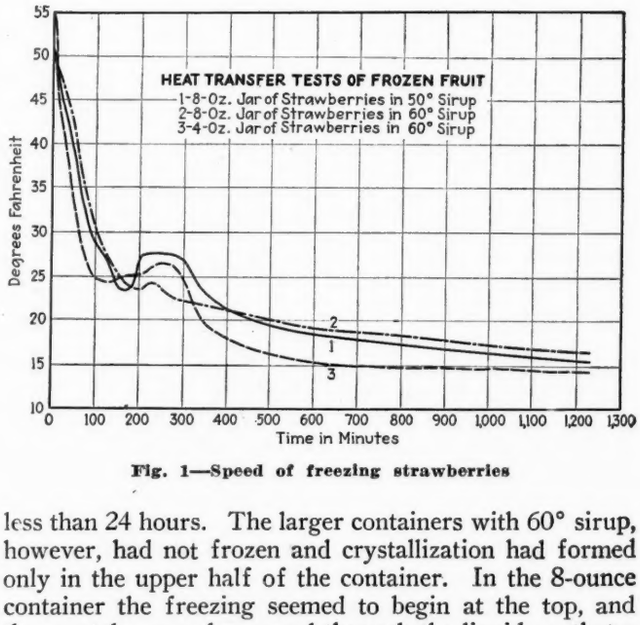


Fig. 1—Speed of freezing strawberries

[1]Ford, K. L., and Osborne, A. G.: "Protection Tubes for Thermocouples for Determining Heat Penetration in Processed Foods." *Ind. & Eng. Chem.*, Vol. 19, page 1,345; December, 1927.

[2]"Preserving Fruits and Vegetables by Freezing," address by H. C. Diehl at National Canners' Association Convention at Chicago, Jan. 22, 1930.

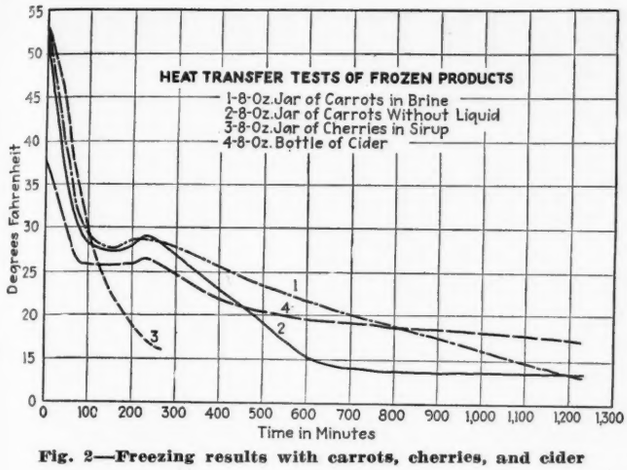


Fig. 2—Freezing results with carrots, cherries, and cider

very heavy sirup remained that would not freeze at this temperature. The 4-ounce container appeared to be completely frozen, however, because interlocking ice crystals prevented the movement of the unfrozen sirup. If agitation had been used to assist in freezing the 8-ounce container, it is doubtful if freezing would have started at one point, and in that case there would not have been a zone of unfrozen liquid remaining.

Inasmuch as strawberries were the only fresh fruit available, it is believed that tests on repacked frozen fruits will give some indication of their general behavior during freezing. Heat transfer in containers of preserved raspberries was considerably more rapid and there was little indication of supercooling.

If it were possible to agitate the containers slightly during the first stages of freezing, the rate of heat transfer would be more rapid; ice formation would begin sooner and be more evenly distributed. Ice crystals in the liquid were large without agitation. Cider was frozen with agitation in 8-ounce beverage bottles more rapidly than when the bottles were stationary, and the ice crystals were smaller. Whether complete freezing is more rapid with agitation is uncertain, for the movement of the liquid ceases long before all the liquid solidifies. It is hoped at a later date to have heat-transfer measurements with agitation that will establish this point.

To determine the heat transfer in vegetable products (Fig. 2), two jars of diced carrots were packed without liquid and with a 2 per cent brine. Little supercooling occurred, and the cooling curves were practically identical until freezing was complete. Beyond that point the carrots packed without brine dropped to cold-room temperature more rapidly, probably because there was less insulating effect than when the brine had frozen.

A second series of measurements was made with frozen fruits that had been allowed to thaw out. Blackberries without sirup, raspberries in a 3 to 1 sucrose sirup, and sour cherries (1 to 1) were used. The rate of cooling differed with the cherries (Fig. 2), which had not begun to freeze at 16° F. The temperature in the containers dropped rapidly until it was within a few degrees of the room temperature in 4½ hours, at which time the test was discontinued. It is doubtful if this product would ever have frozen solid at this temperature, for the cherries in the original containers were only lightly covered with ice.

From the results of those preliminary tests, there appears to be little difference in the freezing rates of small fruits, and that a 24-hour period at 10° F. will be sufficient to freeze the product in an 8-ounce container, except possibly for fruits packed in a very heavy sirup.

Increase in volume caused by freezing does not appear to be a serious factor in the freezing of fruits. A number of 5½-ounce containers, which would vent if the pressure became too great, were packed to different filling levels. The only container from which the liquid was forced out was filled to within $\frac{3}{16}$ of an inch of the top. Normal filling levels with the product under a vacuum seem to be practicable with the glass package. In the case of closures not held on by a vacuum or that do not vent internal pressure, breakage of the containers is likely to occur if they are overfilled, and for this reason such a closure is not recommended.

There is no doubt that the compressibility of the products may vary, and the decrease in head space and amount of bursting pressure exerted on the container will vary. Just what effect this variation will have on the filling levels is a subject for future studies.

Freezing has been suggested as a possibility for preserving certain fruit juices that lose their flavor during pasteurization. For this reason a number of 8-ounce beverage bottles were filled with cider at different ratios of liquid to head space and frozen to observe the behavior of the container. Table I shows the effect of freezing on the internal pressure in the containers.

Table I—Internal Pressure in Containers of Cider After Freezing

Filling Ratio	Vacuum Packed Vacuum in Inches	Packed Without Vacuum Pressure in Pounds
6 to 1	12	2
8 to 1	9	6
10 to 1	3	14

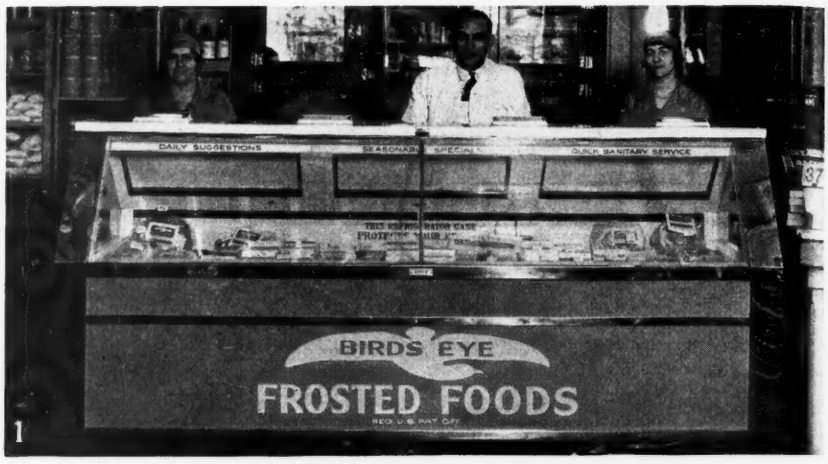
If liquids are packed under a high vacuum (18 to 20 inches) at these filling levels, there is little danger of sufficient internal pressure developing to lift the closure or cause breakage. It should be noted that the vacuum is rapidly overcome during freezing as the filling ratio increases, and that the bottles without a vacuum have considerable pressure when filled at a 10 to 1 ratio. Evidently a 10 to 1 filling ratio should not be greatly exceeded, because of rapidly increasing pressure as the head space is decreased. Vacuumized cider either remained in a supercooled condition longer than the untreated juice or the heat transfer was slower in the absence of air, for ice formation was retarded approximately 30 minutes in these containers.

The curve of heat transfer of cider in an 8-ounce beverage bottle is given in Fig. 2. As in the case of the fruits, supercooling occurs before crystallization begins.

Cider packed at a 6 to 1 and a 10 to 1 ratio, with and without vacuum, was frozen with agitation. Normally, pressures in containers frozen with agitation probably would be more uniform against all parts of the container, but in liquids that undercool and then freeze through the whole mass instantaneously there would be equalization of pressure. If freezing should begin in the neck of the container, it would be more difficult for a normal expansion into the head space to occur. After the initial freezing, agitation would not greatly increase the rate of cooling, as there would no longer be any free moving liquid.

The preliminary tests on the glass container as a package for frozen products appears to be very satisfactory. With the use of proper filling levels, there is little danger of breakage due to expansion. The use of a closure that is held on by vacuum or will vent with high internal pressure is recommended. Heat transfer measures show that fruits have frozen and approach the room temperature of 10° F. within 24 hours.

Display Cases
For Frozen Foods



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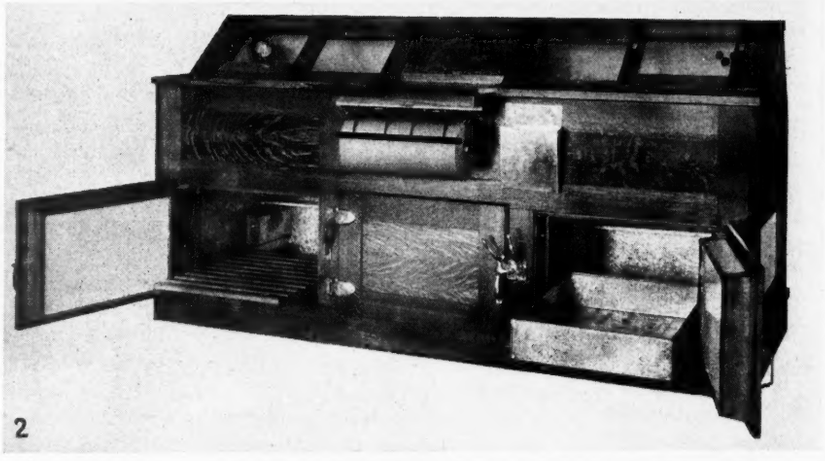
1

THIS CASE is one of the units used in the sales test of quick-frozen foods at Springfield, Mass. Among the particular features of the cabinet are the high insulating qualities and an effective circulating system that gives even distribution of air throughout the display section. Concealed floodlight illumination that eliminates possibility of glare on the display window, and at the same time avoids heating the inside of the case by the bulbs, is a valuable point. Fogging of the glass is prevented by presence of a dehydrating agent in metal tubes between the panes. This Oreole case, a development of Ottenheimer Brothers, Baltimore, Md., also has a generous storage compartment in the rear.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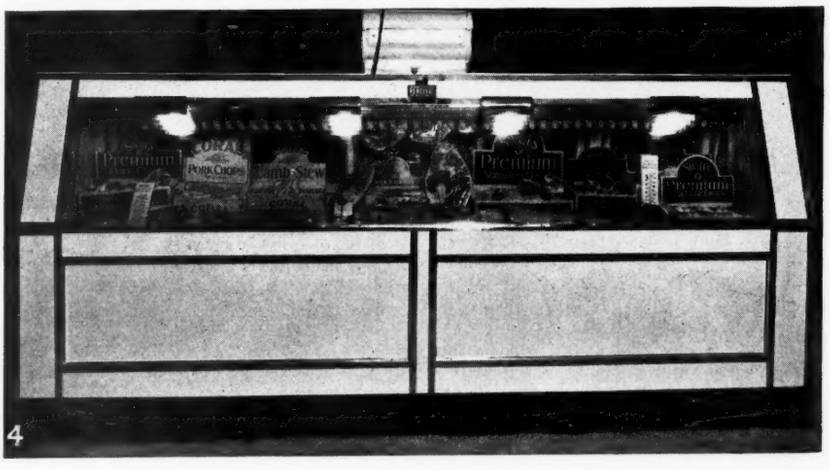
2

A rear view of the "Triple Service Freezer Case," manufactured by National Store Fixture Company, Denver Colo., shows how convenience has been combined with a low rate heat entry. The case is made with either 2 or 3 inches of corkboard insulation on the storage space, and either two or three thicknesses of plate glass, depending upon conditions of operation. The display compartment is divided into a front and rear section one of which maintains products at 10° to 20° F. and the other at 20° to 30° F.

3

3

This Zerozone cabinet, made by the Hussmann Refrigerator Company, St. Louis, Mo., contains both display and storage compartments. It has been designed particularly for the low temperatures necessary for use with frozen products. The unit is cork insulated and is finished in white vitreous enamel with Monel metal trim.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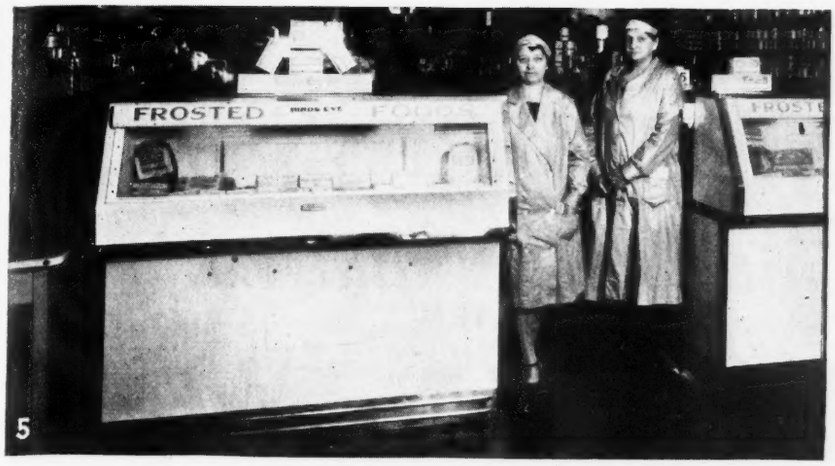
Four-inch cork insulation and four thicknesses of plate glass, on which fogging is prevented by chemical dehydration, give good insulating characteristics to this "Sani-Freez" case of the C. L. Percival Company, Des Moines, Iowa. The rear doors of the display section also are of four layers of plate glass. The 10-foot



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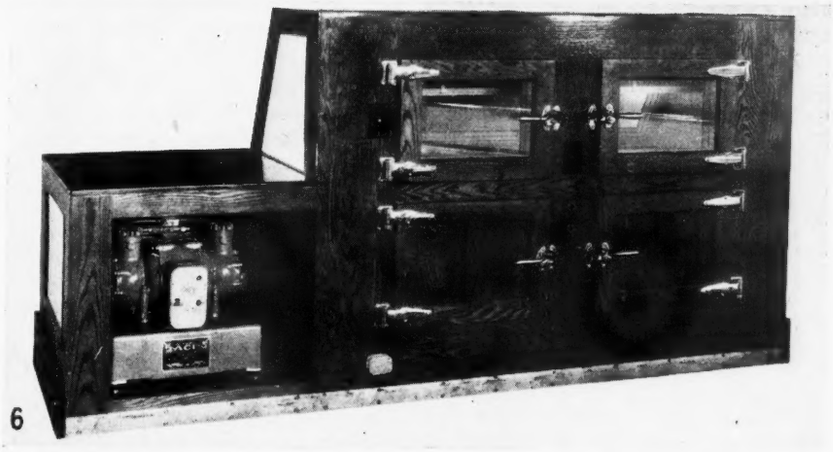
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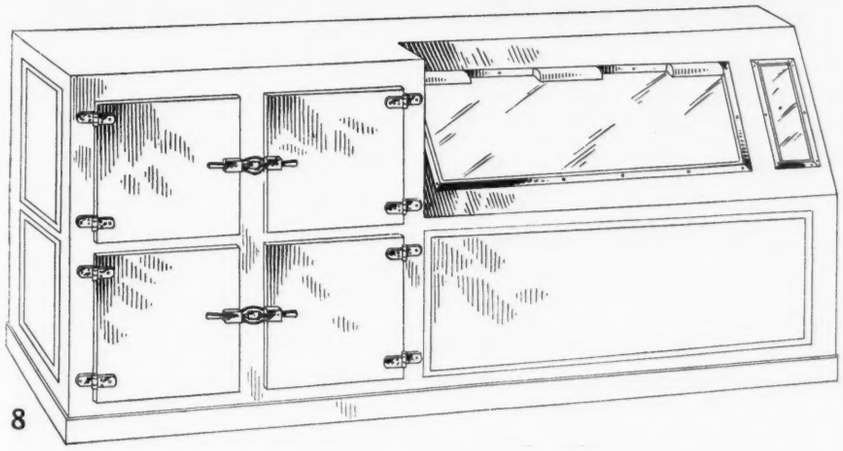
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model illustrated is refrigerated by a ¼-ton Lipman unit in the basement beneath the counter.

5

The Frigidaire cases used in the sales test at Springfield have a bin-type storage portion with hinged covers over the bins. Outflow of cold air from the case when goods are being removed is thus kept at a minimum. The display section in cases of this type is not used for dispensing purposes. The Frigidaire Corporation also is supplying refrigeration units designed for low-temperature work for other case manufacturers.

6

A case in which the space above the refrigerating unit is used as a wrapping counter is offered by the American Foundry Equipment Company, Mishawaka, Ind. The case has been especially designed for use with an American Ace refrigerating unit, Three courses of plate glass are used on the display section. The case is insulated with 4 inches of corkboard sealed with Hydrolene (blown pitch). Cases of the same design are being put out experimentally by the Ligonier Refrigerator Company, Ligonier, Ind.

7

One type of "Dry Cold" cabniet, manufactured by C. V. Hill & Company, Inc., Trenton, N. J., has a revolving display stand for small packages in one end of the display cabinet. This revolving display, upon which patent is pending, attracted considerable attention at the New York meeting of the Institute of American Meat Packers.

8

A unit especially suitable for self-service stores is under construction by the Ford Refrigerator Company, Inc., South Jacksonville, Fla. The display section is not used for dispensing purposes. Forced air circulation by a thermostatically controlled fan is used in the storage section, the air making a circuit around the walls of the display compartment. Refrigerating equipment is now being designed especially for this unit.

In presenting these illustrations of cabinets for frozen-foods, FOOD INDUSTRIES obviously has not attempted to give a complete review of the growing number of satisfactory cases now being produced. The cases illustrated have been selected chiefly because they are typical of present characteristics and trends in design.

QUICK-FREEZING PLANTS

In the United States and Canada

THAT quick-freezing has already reached a fairly large development in the United States is shown by the number of plants known to be in existence at this time. FOOD INDUSTRIES has prepared the following list showing the location and type of plant of all the quick-freezing machinery about which definite knowledge can be obtained. Such a large number of units could come into existence only over a period of several years. Indeed, the commercial development of the quick-freezing process in the United States dates back nearly to the Great War.

Because it is known that additional quick-freezing plants and machines are under construction at the time of writing this article, the point should be kept in mind that after April, 1930, important additions to the list may be looked for.

This list by no means includes all the plants producing frozen foods. If it were to be comprehensive of slow-frozen as well as rapidly-frozen foods if should include every large packing house, practically every large fishing company, every ice cream manufacturer, and a host of miscellaneous industries packing barrelled fruits, juices, poultry, eggs, and the like. The list includes only those plants where special quick freezing machinery is installed. Therefore, such plants as the two at Provincetown, Mass., belonging to the Atlantic Coast Fisheries Company, that are producing processed and quick-frozen fish in a sharp freezer are not a part of the list.

System	Type	Location	Company	Products
Beard	Plate	Ketchikan, Alaska	New England Fish Co.	Fish
Birdseye	Belt	Boston, Mass.	Batchelder & Snyder, Dorr & Doe	Meats
	Belt	Boston, Mass.	Whitman, Ward & Lee	Fish and Sea Foods
	Belt	Gloucester, Mass.	General Seafoods Corp.	Fish
	Belt	Halifax, N. S.	Public Cold Storage Terminal, Ltd.	Fish
	Belt	Hillsboro, Ore.	Ray-Maling Company*	Fruits and Vegetables
Canadian Biological Board	Metal Envelope	Halifax, N. S.	Biological Board Experiment Station	Fish
	Metal Envelope	Lockport, N. S.	†	Fish
	Metal Envelope	Luenburg, N. S.	†	Fish
	Metal Envelope	St. Andrews, N. S.	Biological Board Experiment Station	Fish
Cooke	Continuous Plate (3)	Groton, Conn.	Atlantic Coast Fisheries Co.	Fish
Cooke (Modified)	Block (2)	Groton, Conn.	Atlantic Coast Fisheries Co.	Fish
	Batch Plate	Gimli, Man.	Armstrong-Gimli Fisheries, Ltd.	Fish
	Batch Plate	Halifax, N. S.	National Fish Co.	Fish
	Batch Plate	Jacksonville, Fla.	Atlantic Coast Fisheries Co.	Shrimp
Kolbe	Floating Pan (Experimental Unit)	Austin, Minn.	Geo. A. Hormel Co.	Meats
	Floating Pan	Boston, Mass.	Bay State Fisheries Co.	Fish
	Floating Pan	Boston, Mass.	Booth Fisheries	Fish
	Floating Pan	Boston, Mass.	Quincy Market Cold Storage Co.	Fish
	Floating Pan	Erie, Pa.	Kolbe Fisheries	Fish
	Diving Bell	Erie, Pa.	Kolbe Fisheries	Fish
	Diving Bell	Galveston, Texas	Bay Fisheries Co.	Shrimp and Fish
	Floating Pan	Galveston, Texas	Bay Fisheries Co.	Shrimp and Crab Meat
	Floating Pan	Gloucester, Mass.	Gorton-Pew Fisheries	Fish
	Floating Pan	Hawkesburg, N. S.	Leonard Fisheries Co., Ltd.	Fish
	Floating Pan	Indianapolis, Ind.	Indianapolis Abattoir	Meats
	Floating Pan	Indianapolis, Ind.	Nitterhaus Bros.	Meats
	Floating Pan	Liverpool, N. S.	Seven Seas Fisheries, Ltd.	Fish
	Floating Pan	Port Dover, Ont.	Kolbe Fisheries	Fish
	Diving Bell	Port Dover, Ont.	Kolbe Fisheries	Fish
	Floating Pan	Portland, Me.	H. A. Wilson Co.	Fish
	Floating Pan	Vinalhaven, Me.	Libby-Burshell Fisheries	Fish
Petersen	Can	Bay City, Mich.	Bay City Freezer	Fish
	Can	Detroit, Mich.	(Inoperative)	Fish
	Can	Traverse City, Mich.	Traverse City Packing Co.	Fish and Fruit
	Can	Winnipeg, Man.	†	Fish
Skuce	Rubber Envelope	St. Johns, N. F.	Harvey & Co.	Fish

* Machine not owned by Ray-Maling Co., but used for experimental production under a suitable arrangement.
† Data not at hand.

News of the Month

Corn Sugar Seems Big Source Of Illicit Alcohol

By I. D. Foos
Washington Office
Food Industries

RECENT indictment of corn-sugar manufacturers, yeast companies, and industrial establishments engaged in various branches of the chemical industry has attracted attention to a new phase of alcohol control. As was forcibly developed by Chairman Wickersham of President Hoover's law enforcement body at the Congressional investigation, it concerns the "enormous increase in the sale of corn sirup and corn sugar," ascribed in great part to use for liquor manufacture.

There have been three cycles in prohibition enforcement. In its first stage, the authorities concentrated their energies on preventing diversion of existing stocks of whiskey. Next, they turned their attention to checking widespread diversion of industrial alcohol. Now they are attempting to block the movement of otherwise legitimate products to illicit distilleries, and hence have brought yeast, corn sugar, and other industrial materials into the prohibition limelight.

Through it all, the manufacture of "moonshine," defended by the Southern highlander as a birthright, has persisted. But as the diverted supply of industrial alcohol has diminished, moonshining has assumed the characteristics and proportions of an industry. The moonshiner's kettle in the swamps and mountains has been supplemented by column stills, operated on a factory scale, located in or close to all the larger cities, particularly in the North. Here corn-sugar mash is used in preference to cane and beet sugar, cornmeal, or molasses, because of its rapid fermentation. Usually, it is necessary only to add yeast to this mash as the protein content of the grades of sugar used provide sufficient yeast food so that it produces a ripe mash in 24 hours when accelerated by heat. Ordinarily, such corn sugar also enjoys a price differential of approximately $1.50 per hundredweight; that is, of course, an advantage, even though cost is not a primary factor in this business.

As the drive against diversion of industrial alcohol has continued, seizures made by prohibition agents have revealed that the number of corn-sugar stills is increasing rapidly. Until recently the stills seized were not classified in reports made to headquarters in Washington according to materials used, but since Jan. 1, the Bureau of Prohibition has kept a record of the number of stills seized throughout the country classified according to capacity and the kind of mash used. This record, based on incomplete reports for the month of January, from 17 out of 27 administrative districts, reveals that one-half of all the stills seized were using corn sugar. Even more significant is the fact that the number of corn sugar stills of the largest rating according to capacity is an even greater percentage of the total seized.

Prohibition authorities admit that this is circumstantial evidence, but they contend that the record of seizures truly reflects the situation in illegal alcohol manufacture as it exists today. They claim, furthermore, that this raw material would be still more widely used if as generally available as cane sugar. It is because of the growing importance ascribed to large corn sugar stills that they are preparing to prosecute the indictment that have been returned against firms supplying corn sugar, yeast, and other raw materials to the distilleries manufacturing illicit liquor on a large scale.

Estimated at one billion pounds last year, the production of corn sugar has increased sevenfold since 1921, as shown in the table below.

Unfortunately, there are no comprehensive statistics on either the food or the industrial uses of corn sugar, but it is believed by prohibition authorities that the legal uses are still relatively small and that the diversion into illegal channels now represents a substantial part of the industry.

More Fish Frozen Last Year; Large Gain in Cured Fish

DURING 1929 the 166 public and private warehouses in the United States reported freezing of 121,542,389 pounds of fish by 121 public and private plants. This is the largest amount frozen in any one year for which there are records, exceeding the amount frozen in 1928 by 7 per cent, according to the Bureau of Standards.

Over one-half of the total consisted of 6 species of fish. Ranked in order of importance they were: Halibut, with 12 per cent of the total; salmon, 10 per cent; mackerel, 9 per cent; cod, haddock, hake, and pollock, 9 per cent; whiting 7 per cent; and sea herring 7 per cent. Other species of which considerable quantities were frozen were shellfish, squid, croaker, butterfish, and lake herring. The largest quantities were frozen during the months of June, July, August, and September, with a general slackening during the latter months of the year, and during the winter months from January to May. The holdings during the year 1929 averaged about 56,000,000 pounds monthly, ranging from a low of 32,000,000 pounds in April to a high of 79,000,000 pounds in November. The average monthly holdings in 1929 were 17 per cent greater than the normal monthly holdings during the 5-year period from 1924 to 1928.

During 1929 the average monthly holdings of cured herring and mild cure salmon were about 26,000,000 pounds. This is an increase of 16 per cent when compared with the average monthly holdings for the 5-year period from 1924-28.

Table I—Illicit Alcohol Stills Seized During January, 1930, Classified by Capacities and Raw Materials

According to Incomplete Reports Received by the Bureau of Prohibition for 17 Out of 27 Administrative Districts

Capacity	No.	Corn Sugar No.	Corn Sugar Per Cent of Total	Cane and Beet Sugar No.	Cane and Beet Sugar Per Cent of Total	Cornmeal and Other Grains No.	Cornmeal and Other Grains Per Cent	Molasses No.	Molasses Per Cent	Denatured Alcohol and Alcoholic Preparations No.	Denatured Alcohol and Alcoholic Preparations Per Cent
Less than 100 gal.....	807	392	48	308	38	69	9	16	2	22	3
100 to 500 gal.....	603	308	51	223	37	31	5	7	1	34	6
500 gal. or more.....	142	91	63	23	16	2	2	5	4	21	15
Total.....	1552	791	51	554	35	102	7	28	2	77	5

Table II—Production of Corn Sugar in the United States, 1909–1928

Calendar Year	Production (Lb.)	Value
1909	159,060,478	$3,600,000
1914	174,368,818	.....
1919	157,276,442	9,314,977
1921	152,055,872	4,542,238
1923	537,909,513	16,797,033
1924	557,160,516	.....
1925	580,370,043	19,505,495
1926	696,838,194	.....
1927	904,830,682	25,635,262
1928	968,600,525	.....

Source: Census of Manufactures, U. S. Department of Commerce.

Sugar Tariff Raised as Senate Trades Votes; Few Other Foodstuff Changes

By Paul Wooton
Washington Correspondent

CUBAN SUGAR is slated for a tariff duty of 2 cents per pound as the bill left the Senate. The House rate was 2.40 cents and the existing rate is 1.76 cents. After so many rate shifts and vote reversals, it is difficult to say what is coming next, but the 2-cent compromise seems to have at least an even chance with the conference committee between House and Senate which will play a decisive part in the last phases of tariff making.

Although sugar was put back to the existing level by a decisive vote in February when the Senate sat as a committee of the whole, the low-tariff coalition broke down after the bill was placed before the Senate early in March. Vote trading on key commodities is generally charged as the reason for the decidedly upward rate trend that followed. The tariff status of sugar seemed to be mixed up with that of petroleum, lumber, cement, and other items around which ranged a fierce debate, and tended to obscure in the public eye some of the more important features of the bill, such as the flexible provisions and the great sweep of upward revisions through nearly every schedule. Aside from sugar, however, the spectacular events of the past month have had little effect on foodstuffs.

Among the Senate changes during the past month, sugar sirup has been restored to existing rates. Blackstrap molasses remains so far at a rate approximating the existing level of one-sixth cent per gallon, although the basis has been changed to that of total sugars.

Swedish bread was put back on the free list from a 30 per cent duty previously applied. Countervailing duties were placed on bread not including Swedish. Maraschino cherries took an increase to 9½ cents per pound plus 40 per cent *ad valorem*. The rates on preserved and packaged dates were increased, and those on bulk dates were reduced from the level formerly proposed.

Among other minor tariff changes on foodstuffs was the increase in the rate on lemons from 2 to 2½ cents per pound. Mustard seed was put back to 2 cents per pound. With Romano cheese at 8 cents per pound are classified Romanello, Kefalotyri or Vize and Casseri cheeses; Feta White is at 5 cents per pound. Citrous fruit juices for beverage purposes are at 70 cents per gallon. All frozen berries go to 35 per cent *ad valorem*. The compound rate of 10 cents per pound plus 45 per cent has been restored on preserved mushrooms. Crude beeswax is at 12 per cent; bleached at 25 per cent. Maple products withstood a move to decrease and are at 8 cents per pound for maple sugar and 5½ cents for maple sirup.

The fate of pending legislation to establish statutory standards for preserve, jelly, and jam depends on whether the House committee on Agriculture decides to proceed before the Food and Drug Administration has exhausted all means of obtaining relief in the courts. Although federal district courts at Detroit and Indianapolis have ruled against the Food and Drug Administration in seizure cases involving "Bredspred," a product of the Glaser, Crandell Company, Chicago, the Administration claims that there has never been a trial on the merits of its contention that "Bredspred," although sold under a distinctive name, should properly be labeled "imitation."

Recalled by the House committee on March 19 to explain why the Food and Drug Administration has not prosecuted an appeal from these adverse decisions, W. G. Campbell, chief of the Administration, and J. F. Moore, assistant to the solicitor, stated that an appeal from the judgment of the Detroit court had been blocked by an order of the court releasing the goods, and that since then their hands had been tied by the temporary injunction obtained in February, 1927, by the Glaser, Crandell Company in the federal district court at Chicago. Although three years have elapsed since this injunction was entered, Mr. Moore explained that the department has not been able to obtain a final hearing.

For the third time in nine years, the slack package bill passed the House on March 17. Under the bill, slack filling of food containers in such a manner as to deceive or mislead purchasers becomes a violation of the Food and Drugs Act. In enforcing this provision the Food and Drug Administration is instructed to permit reasonable variations and to make due allowance for shrinkage or expansion. The bill also subjects to condemnation packages shaped in such a manner as to be deceptive of the quality, quantity, size, kind, or origin of the contents. Representative Stafford, of Wisconsin, objected to giving to government bureaucrats what he described as the right to fix the form of containers, but he did not block consideration of the bill, which came up on the unanimous consent calendar.

Representative Stafford pressed his objection to consideration of the Mapes bill for amending the Food and Drugs Act to require that substandard canned foods shall be labeled as such. Canners anticipate that the enactment of this legislation will greatly stimulate their business by promoting public confidence in canned foods. They prefer the Mapes bill to the more elaborate provisions of the Hope bill, under which the Food and Drug Administration would be authorized to establish definitions for all grades of canned foods for the benefit of manufacturers desiring to employ them.

COMING EVENTS

APRIL

2-3—Tri-State Packers' Association. Baltimore, Md.
7-11—American Chemical Society, Atlanta, Ga.
23-24—American Dry Milk Institute, Chicago, Ill.

MAY

5-9—American Association of Cereal Chemists, Chicago, Ill.
14—American Spice Trade Association, New York City.

Loss in Hams Preventable By Proper Chilling

SOURING of hams during the process of curing can be prevented almost entirely by prompt and thorough chilling immediately after hogs are slaughtered, and by maintenance of proper curing temperatures, declares Dr. John R. Mohler, Chief of the Bureau of Animal Industry, U. S. Department of Agriculture. This finding, which supplements previous reports of research work, results from studies in 13 large plants located in regions of large-scale hog production.

The observations covered a period of 12 months, in which 7,338,535 hogs were slaughtered in the 13 establishments where ham-souring records were kept. In all, 66,731 hams were found to be affected, causing an estimated loss, from that cause, of approximately $100,000, assuming that the average loss per ham was $1.50. If the same proportion applied to the total slaughter under federal meat inspection for the last fiscal year, the loss would amount to $650,000. Moreover, since federal inspection represents only about two-thirds of the slaughter of hogs in the United States, the total loss from sour hams is estimated to be close to a million dollars.

"The indicated loss is almost entirely preventable," Dr. Mohler says, explaining that rapid and thorough chilling immediately after slaughter, followed by low temperature until the meat is cured, will prevent the sour condition. This opinion is supported both by scientific research and by the results of the study just completed. In one establishment souring developed in only four hams out of each 100,000 available for curing; this plant was using an efficient system of chilling the meat immediately after the hogs were killed. At another plant the corresponding number of sour hams found was 1,452, or over 360 times as many. The 11 remaining plants showed intermediate losses.

The extent of ham souring in different establishments, according to the study, is governed almost entirely by the temperature factor. The location of plants, volume of business, curing ingredients, and other factors appeared to have no bearing on ham-souring losses.

Bakery Engineers Have Record Meeting; Sliced Bread Discussed

BROADENING the field of activity of the bakery engineer beyond the specific duties of production is the ambitious and enthusiastic purpose of the American Society of Bakery Engineers, as expressed by the leading speakers in their recent convention held at the Edgewater Beach Hotel in Chicago. This meeting broke all previous records for attendance, with a registration of 577, or 86 more than in 1929.

In an inspiring address delivered the morning of the second day, Murray Guthrie, of Minneapolis, pointed out that the bakery engineers' function is not only to make a good loaf of bread, but to make a better loaf, and to assume at least part of the responsibility of seeing to it that the loaf is received and enjoyed by the consumer; all to the end that sales shall be augmented. "The production man's responsibility does not end with the end of the production line. . . . He must become sales minded," said Mr. Guthrie. He must be ever alert to the opportunity of bringing out new products. After thorough investigation and practical research, as to salability, he should use his best efforts to "sell" his product to his own sales organization. In this way he can prove to be of greater value to his company, with consequent bettered economic status.

In keeping with the general theme of the meeting, several members discussed the possibilities inherent in sweet goods and cakes. A chart summarizing a survey recently conducted among a large number of homes showed that commercial bakers are making but 20 per cent of the cakes so consumed. It was felt that by making cakes on approximately the same formulas as are used in the homes, this relatively large market could be developed.

Sliced bread was discussed at a special evening session, at which were treated such matters as formulas, the arrangement of slicing and wrapping equipment, taking proper care of the slicer, mold, packaging, and the cost of slicing.

Of especial interest was the chart showing the cost of slicing and packaging sliced bread, based upon data gained by the pre-questionnaire method. Although slicing machines have not been in use long enough to determine accurate figures, it is assumed that they will last 2 years. On the basis of 1,000 loaves of bread, lowest cost, the highest cost, and the average cost of slicing are shown below.

Cost of	Lowest Cost	Highest Cost	Average Cost
Trays	$2.86	$3.16	$3.10
Labor cost of slicing	0.60	2.11	1.31
Depreciation	0.75	2.01	1.19
Repairs	0.10	1.45	0.44
"Cripples"	0.08	0.48	0.34
Total	$4.39	$9.21	$6.38

At the average rate, the added cost of slicing represents 9.13 per cent of a loaf selling for 7 cents, 7.97 per cent of an 8-cent loaf, and 6.38 per cent of a 10-cent loaf. This additional charge should, of course, be passed on to the consumer in the form of a higher price for the sliced loaf. Certainly, all technical requirements—including a slightly higher percentage of milk solids than is customary—of a loaf intended for slicing must be met fully, inasmuch as such a loaf must have a firm crumb, a soft crust, be of even texture and close grain, and must not crumble. The consumer demands that sliced bread look, taste, and keep well.

Because of the fact that a loaf is rarely used in its entirety at one meal, the resultant problem of keeping the slices close together in order to avoid drying out, or molding, lends importance to the methods of packaging sliced bread. Various trays and methods of packaging were illustrated and discussed. Co-ordination of the slicer and the wrapping machine is receiving attention by machinery manufacturers, at least one design of machine having it worked out on practically an automatic basis.

Officers elected for the coming year are: Louis E. Caster, of Rockford, Ill., president; Earl A. Cox, Jamaica, N. Y., first vice-president; John C. Summers, New York City, second vice-president; and Victor E. Marx, Chicago (re-elected), secretary and treasurer.

New Construction

Bakery—Claussen Bakeries, Greenville, S. C., awarded contract for a 2 story bakery, to Claussen-Lawrence Construction Co., 1394 Gwinnett St., Augusta, Ga. Estimated cost $200,000.

Bakery—Constructing Quartermaster, Camp Devens, Ayer, Mass., awarded contract for the construction of a 2 story bakery to Central Engineering & Construction Co., 210 Main St., Pawtucket, R. I. Estimated cost $15,000.

Bakery—H. S. Harber, 125 East 38th St., New York, N. Y., will soon award contract for remodeling building at 51 Christopher St. for baking plant. Estimated cost $40,000. W. B. B. Willis, 171 Madison Ave., New York, is architect.

Bakery—I. Keil, 349 Hawthorne Ave., Newark, N. J., will soon award contract for the construction of a 1 story addition to bakery including baking ovens, mixers and bakery machinery. Estimated cost $40,000. F. P. Friedman, 395 Springfield Ave., Newark, is architect.

Bakery—National Biscuit Co., 89 9th Ave., New York, N. Y., plans the construction of a bakery. Estimated cost to exceed $1,000,000. Indefinite when project will mature.

Bakery—Nauer Baking Co., Beeville, Tex., plans a 2 story addition to bakery including new equipment. Estimated cost $45,000. Dielmann & Levy, State National Bank Bldg., Corpus Christi, are architects.

Bakery—C. J. Patterson Corp., 4050 Penn St., Kansas City, Mo., awarded contract for the construction of a 1 story bakery at Memphis, Tenn., to Fogel Construction Co., 619 Reliance Bldg., Kansas City.

Bakery—White House Baking Co., 11 Florence Pl., Lawrence, Mass., is receiving bids for a 2 story addition to bakery. Estimated cost $40,000. J. G. Morissette, 575 Essex St., Lawrence, is architect.

Bakery—J. Wingarten, 1502 Main St., Houston, Tex., will soon award contract for a 1 story, 100 x 120 ft. bakery at Navigation Blvd. and Lockwood St. J. Finger, Democratic Bldg., Houston, is architect. McCormick Co., Inc., 121 South Negley Ave., Pittsburgh, Pa., are associate architects.

Bottling Plant—Coca Cola Bottling Co., Greenville, S. C., will soon award contract for the construction of a 2 story bottling plant. Estimated cost $100,000. J. E. Sirrene & Co., Greenville, are engineers.

Bottling Plant—L. P. Croce Inc., 930 Summerfield Ave., Asbury Park, N. J., will receive bids about Apr. 1 for the construction of a 1 story bottling plant. Estimated cost $40,000. C. B. Cook, Asbury Park Trust Bldg., Asbury Park, is architect.

Bottling Plant—Greenville Coca Cola Bottling Co., Greenville, S. C., awarded contract for a 2 story bottling plant to Morris-McKoy Building Co., Greenville. Estimated cost $100,000.

Brewery—Noffke, Morni & Sylvester, Metcalfe St., Ottawa, Ont., archts., will soon receive bids for the construction of a 4 story brewery for Capital Brewing Co. Ltd., Wellington St., Ottawa. Estimated cost $250,000. Vats, electric refrigerator, cooling rooms, central heating plant, etc. will be installed.

Distillery — Federal Distilleries Ltd., 6659 Park St., Montreal, Que., plans the construction of a distillery. Estimated cost $150,000.

Warehouse—Memphis Bottlers Supply Co., E. J. Koller, Mgr., 137 Calhoun Ave., Memphis, Tenn., awarded contract for a warehouse at 97 Iowa St. to F. J. Ozanne & Co., Empire Bldg., Memphis. Estimated cost $16,000.

Grape Juice Plants and Canneries—Welch Grape Juice Co., c/o E. Welch, Westfield, N. Y., had surveys made and will submit report to French Government for establishing grape juice plants and canneries in Morocco and French provinces in North Africa. Estimated cost to exceed $1,000,000.

Mineral Water Plant—Nemasket Spring Water Co., N. C. Kayajiah, Middleboro, Mass., awarded contract for a 2 story plant on Plymouth St. to C. R. Hosford, Middleboro. Estimated cost $40,000.

Candy Factory Addition—Daggett Chocolate Co., 408 Main St., Cambridge, Mass., is having preliminary sketches made for addition to candy factory. Estimated cost $40,000. Private plans.

Canning Plant (Pea)—Utah Packing Co., 537 South State St., Salt Lake City, Utah, awarded contract for a 3 story pea canning plant at Franklin, Idaho, to C. F. Dinsmore & Co., Ogden, Utah. Estimated cost $75,000.

Canning and Packing Plant—Lakemont Packing Co., Sebring, Fla., plans to rebuild canning and packing plant destroyed by fire. Loss $100,000.

Canning Plant—The Purchasing & Holding Co., Reseda, Calif., manufacturers of Runnymede canned chicken, awarded contract for the construction of a 1 story, 55 x 185 ft. canning plant to The Austin Co., 16112 Euclid Ave., Cleveland, O. Estimated cost $75,000.

Creamery—American Creamery Co., 1433 Cypress Ave., Oakland, Calif., will build a 2 story, 170 x 180 ft. creamery, will have 10,000 lbs. butter, 5,000 gal. cream and 10,000 to 15,000 gal. milk daily, at 14th and Poplar Sts. Estimated cost $200,000. Private plans. Work will be done by day labor.

Creamery—O. A. Archer, Bustow, Okla., plans the construction of a new creamery at Wagoner. Estimated cost $25,000. Private plans.

Creamery—Farmers Co-Operative Creamery Co., Cordell, Okla., is having plans prepared for the construction of a creamery. Estimated cost $30,000. Private plans.

Creamery — Farmers Union Co-Operative Creamery Co., 201 Oak St., Kansas City, Mo., awarded contract for the construction of a 1 and 2 story, 60 x 210 ft. creamery at Wakeeney, Kan., to Chalmers and Barton, 620 Pioneer Trust Bldg., Kansas City. Estimated cost $80,000.

Creamery and Butter Plant — Co-Operative Creamery Co., Elk City, Okla., is having plans prepared for the construction of a new creamery and butter plant. Estimated cost $30,000. Private plans.

Creamery Plant Addition — Standard Creameries Co., Ltd., 2743 San Pablo Ave., Oakland, Calif., awarded contract for addition to creamery plant, to W. K. Owen, 3145 Pleitner Ave., Oakland. Estimated cost $110,000.

Dairy Plant—Hazel Glen Milk Co., C. E. Hastie, 5011 Second Ave., Pittsburgh, Pa., is having plans prepared for the construction of a 2 story, 50 x 100 ft. dairy plant on Second Ave. Architect not announced.

Dairy Plant—H. P. Hood & Sons, 135 Harris Ave., Providence, R. I., awarded contract for a 2 story, 15 x 120 ft. dairy plant on Harris Ave., to W. F. Cruise Construction Co., 19 Dexter St., Pawtucket. Estimated cost $25,000.

Dairy Plant—Willow Brook Dairy Inc., 19th and Telegraph Ave., Oakland, Calif., is receiving bids for the construction of a 1 and 2 story dairy plant at San Pablo Ave. and Athens St. Estimated cost $65,000. Diggs & Marshall, Inc., Latham Sq. Bldg., Oakland is architect.

Ice Cream Plant—San Angelo Dairy Products Co., c/o L. E. Erwin, San Angelo, Tex., plans construction and remodeling of ice cream plant. Estimated cost $75,000. Private plans. Work will be done by day labor. Machinery and equipment contract awarded.

Milk Plant—Alderney Dairy Co., 26 Bridge St., Newark, N. J., will build a 2 story, 45 x 138 ft. milk plant including milk tanks, sterilizing machinery and equipment, etc. at South Columbia, N. Y. Estimated cost $40,000. W. E. Lehman, 972 Broad St., Newark, is architect.

Milk Depot, Etc.—Hegeman Farms, 325 Center St., Brooklyn, N. Y., will soon award contract for a 2 story, 75 x 100 ft. milk depot, etc. at Center St. and Wyckoff Ave., Ridgewood. Estimated cost $40,000.

Milk Depot, Etc.—H. Sacks, De Witt and Williams Ave., Brooklyn, N. Y., plans a 2 story, 101 x 103 ft. milk depot and storage building. Estimated cost $40,000. M. Perlstein, 6735 75th St., Middle Village, is architect.

Milk Distribution Plant—Renken Dairy Co., 584 Myrtle Ave., Brooklyn, N. Y., plans the construction of a milk distribution plant at Maple Ave. and Long Beach Rd., Rockville Center. Estimated cost $200,000.

Pasteurizing Plant—Lauderdale Dairies Inc., M. G. Ness, c/o Chamber of Commerce, Meridian, Miss., plans the construction of a pasteurizing plant at 5th St. and 31st Ave. Estimated cost $35,000.

Pasteurizing Plant—Spears Dairy, Inc. c/o C. D. Spears, Beaumont, Tex., awarded contract for the construction of a 1 and 2 story, 40 x 80 ft. milk pasteurizing plant, to H. Weber, Beaumont. Estimated cost $75,000.

Powdered Milk and Ice Cream Plant—Federal Milk Co., Van Ness Ave. and Market St., San Francisco, Calif., plans the construction of a plant for the manufacture of powdered milk and ice cream at Y St., Sacramento. Estimated cost to exceed $40,000.

Cold Storage Warehouse—Scobey Fireproof Storage Co., F. E. Scobey, Pres., 311 North Medina St., San Antonio, Tex., will receive bids after Apr. 15 for the construction of a 4 story, 100 x 166 ft. cold storage warehouse at 300 Blk. No. Medina St. Estimated cost $225,000. Engineering Service Corp., 1806 Post Dispatch Bldg., Houston, is architect and engineer.

Cold Storage Plant—U. S. Government, c/o A. W. Parker, Constructing Quartermaster, Randolph Field, Schertz, Tex., is having preliminary plans prepared for the construction of a post exchange building including cold storage plant at Randolph Field. Estimated cost $75,000.

Cold Storage Warehouse, Creamery, etc.—Union Storage & Transfer Co., Fargo, N. D., awarded contract for the construction of a 4 story, 100 x 115 ft. cold storage warehouse, 3 story, 76 x 132 ft. creamery building, etc., to Meinecke & Johnson Co., Fargo. Estimated cost $250,000.

Ice and Cold Storage Plant—City Ice & Fuel Co., H. D. Norville, Pres., 6611 Euclid Ave., Cleveland, O., is having plans prepared for the construction of a cold storage plant including equipment at 15th, Pike and Penn Sts. Estimated cost $2,500,000. Ball Ice Machine Co., 126 Choute St., St. Louis, Mo., is engineer. W. Schmidt, c/o owner, is company engineer.

Ice and Storage Plant—Consolidated Ice Co., 13th and Pike Sts., Pittsburgh, Pa., plans the construction of a 7 story, 100 x 350 ft. ice and storage plant. R. Lochmiller, 13th and Pike Sts., Pittsburgh, is engineer.

Ice Plant—American Service Co., c/o J. H. McKinney, Goose Creek, Tex., will build a 25 ton ice plant including 100 ton storage vault at Highlands. Estimated cost $60,000. Private plans. Work will be done by owners forces.

Ice Plant—D. Fazzio, Shreveport, La., is having plans prepared for the construction of a 25 x 50 ft. ice plant. Estimated cost $10,000. E. A. George, Shreveport, is architect.

Ice Manufacturing Plant—Hygienic Ice Corp., 881 State St., New Haven, Conn., awarded contract for the construction of an ice manufacturing plant at West Haven to C. W. Murdock Co., 505 Grand St., New Haven. Estimated cost to exceed $40,000.

Ice Plant—Pascagoula Cold Storage & Ice Co. Inc., W. L. Lindinger, Pascagoula, Miss., is having plans prepared for the construction of a 1 story ice plant. Estimated cost $45,000. E. K. Strahan, Pere Marquette Bldg., New Orleans, La., is consulting engineer.

Refrigeration Plant — Dry Ice Corp., c/o Austin Co. of California, 777 East Washington St., Los Angeles, Calif., Archts. and Engrs., awarded contract for a 1 story, 110 x 147 ft. factory at 2618 Pitt St. to H. M. Baruch Corp., 1015 Lincoln Bldg., Los Angeles. Estimated cost $30,000.

Glass Food Container Factory—Capstan Glass Co., G. F. Rieman, Pres., Connellsville, Pa., is receiving bids for a 1 story, 150 x 340 ft. glass food container factory. P. M. Piazzoli, c/o owner, is engineer.

Grocery Plant—A. H. Perfect Co., 440 East Columbia St., Fort Wayne, Ind., (wholesale grocer) will soon award contract for the construction of a 3 story, 60 x 125 ft. plant. Estimated cost $52,000. A. M. Strauss, 415 Cal-Wayne Bldg., Fort Wayne, is architect.

Grocery Warehouse—Model Grocery Co., 250 East Colorado St., Pasadena, Calif., plans the construction of a 3 story grocery warehouse, etc. at Oak Knoll Ave., Los Angeles. Estimated cost $250,000. Marston & Maybury, 25 South Euclid Ave., Pasadena, are architects.

Grocery Warehouse—National Grocery Co., Western and Madison Sts., Seattle, Wash., awarded contract for the construction of a 106 x 206 ft. warehouse, and garage to The Austin Co., 16112 Euclid Ave., Cleveland, O. Estimated cost $200,000.

Lard Refinery—C. M. Bress, Pedras Negras, Mexico, and Eagle Pass, Tex., plans a lard refinery and can plant in connection, as containers for lard. Estimated cost $45,000. Private plans. Machinery and equipment will be installed.

Macaroni Factory—Roman Macaroni Co., 35-18 37th St., Long Island City, N. Y., plans the construction of a 3 story, 69 x 90 ft. factory at 8th and Pierce Aves. Estimated cost $40,000.

Relish Plant—California Supply Co., 738 Folsom St., San Francisco, Calif., (relishes, etc.) is receiving bids for a 2 story plant at 7th and Brennan Sts. Estimated cost exceed $40,000. Krafft & Sons, Phelan Bldg., San Francisco, are architects.

Salt Plant—General Salt Co., 530 West 6th St., Los Angeles, Calif., plans the construction of a factory for the manufacture of iodine at Huntington Beach. Estimated cost $75,000.

Salt Plant—Forcester Salt Co., 71 Murray St., New York, N. Y., awarded contract for a 1 story, 130 x 215 ft. salt plant, etc. at Silver Springs to J. W. Ferguson Co., 152 Market St., Paterson, N. J. Estimated cost $150,000.

Salt Refinery—Consumers Salt Co., c/o H. A. Pitts, El Paso, Tex., is having preliminary surveys made for the construction of a salt refinery. Estimated cost $30,000.

Sugar Plant—Holly Sugar Co., Tracy, Calif., plans the construction of a group of buildings including one main building and one pump drier building. Estimated cost $500,000.

Yeast Distribution Plant—P. F. Crenshaw, 203 South Camilla St., Memphis, Tenn., plans the construction of a 1 story, 50 x 140 ft. yeast distribution plant and office at South Camilla St. between Union and Eastmoreland Aves. Estimated cost $18,000. Standard Brands Inc., 210 North Main St., Memphis, (distributors of Fleischmann products) is lessee.

Alfalfa Feed Mill—Mason Mills Inc., Pauls Valley, Okla., plans the construction of a new alfalfa feed mill. Estimated cost $30,000. G. W. Fisher, Pauls Valley, is engineer.

Alfalfa Grinding Mill—Denver Alfalfa Milling & Produce Co., Lamar, Colo., plans the construction of a plant to grind and prepare alfalfa meal at Sugardale. Estimated cost $50,000.

Flour Mill—Theodore Stivers Milling Co., West Bldg., Rome, Bldg., awarded contract for a 6 story, 40 x 90 ft. flour mill, 2 story, 40 x 90 ft. warehouse and storage bins, 50,000 bu. capacity, to Jones-Hettelsater Co., 600 Mutual Bldg., Kansas City, Mo. Estimated cost $150,000.

Flour Mill—Vitamin Milling Co. of Canada Ltd, 503 McKinnon Bldg., Toronto, Ont., plans the construction of a flour mill at Tavistock. Estimated cost $75,000. N. O. Heipel, Preston, is architect.

Grain Elevator — Co-Operative Elevator & Supply Co., Meade, Kan., will soon award contract for the construction of a 49 x 69 ft. grain elevator, 125,000 bu. capacity including 14 storage bins. Estimated cost $45,000. Horner & Wyatt, 468 Bd. of Trade Bldg., Kansas City, Mo., are architects.

Grain Elevator — Co-Operative Equity Exchange, Cimarron, Kan., is having preliminary plans prepared for the construction of a grain elevator, 100,000 bu. capacity including fourteen bins. Horner & Wyatt, 468 Bd. of Trade Bldg., Kansas City, Mo., are architects.

Grain Elevator—Fowler Equity Exchange, Fowler, Kan., will soon award contract for the construction of a 45 x 69 ft. grain elevator, 180,000 bu. capacity including six round bins and two intersteel bins. Estimated cost $40,000. Horner & Wyatt, 468 Bd. of Trade Bldg., Kansas City, Mo., are architects.

Grain Elevator—G. Gano, Hutchinson, Kan., awarded contract for the construction of a grain elevator including 24 concrete tanks, head house, 200 ft. high to J. T. McDowell Construction Co., 817 17th St., Denver, Colo. Estimated cost $200,000.

Grain Elevator—General Mills Inc., Chamber of Commerce Bldg., Minneapolis, Minn., awarded contract for the construction of a grain elevator, 1,176,000 bu. capacity at Wichita Falls, Tex. to Barnett & Record Co., 700 Flour Exchange Bldg., Minneapolis. Estimated cost $300,000.

Grain Elevator—Great Northern Ry. Co., St. Paul, Minn., awarded contract for addition to grain elevator, 3,000,000 bu. capacity at Superior, Wis. to Burrell Engineering Co., 400 West Madison St., Chicago, Ill.

Grain Elevator—Minneola Co-Operative Exchange, Minneola, Kan., will soon award contract for the construction of a 51 x 71 ft. grain elevator, 150,000 bu. capacity including 15 storage bins. Estimated cost $50,000. Horner & Wyatt, 468 Bd. of Trade Bldg., Kansas City, Mo., are architects.

Grain Elevator—Port Commission, B. C. Allen, Dir., Houston, Tex., awarded contract for the construction of a grain elevator to Folwell Engineering Co., 333 North Michigan Ave., Chicago, Ill. Estimated cost $1,500,000.

Grain Elevator—The Shepherd Construction Co., Dalhart, Tex., plans the construction of a grain elevator at Lark, near Groom. Estimated cost $75,000. Private plans. Machinery and equipment will be required. Work will probably be done by owner's forces.

Grain Elevator—Standard-Tilton Milling Co., Planters Bldg., St. Louis, Mo., awarded contract for the construction of a 26 x 109 ft. grain elevator at 123 West Broadway, Alton, Ill., to Stevens Engineering & Construction Co., Landreth Bldg., St. Louis. Estimated cost $65,000.

Grain Elevator—Texas City Terminal Ry. Co., c/o H. B. Moore, Pres., Texas City, Tex., plans addition to grain elevator, 1,500,000 bu. additional, present capacity 500,000 bu. Estimated cost $2,000,000. Private plans.

Grain Warehouse—National Milling Co., Front St., Toledo, O., plans the construction of a warehouse for grain elevator at Paine and Front Sts. Estimated cost $600,000.

Seed Cleaning Plant—W. A. Jenkins Mfg. Co., King and Talbot Sts., London, Ont. (manufacturers of stock foods) will receive bids end of April for a 4 story, 70 x 110 ft. seed cleaning plant. Estimated cost $50,000. Interested in prices, etc. on complete equipment.

Packing Plant—J. Baum Packing Co., Third and Central Sts., Kansas City, Mo., plans addition to packing plant. Estimated cost $40,000. Private plans.

Packing House—Gregg Maxcy, Sebring, Fla., plans to rebuild packing house destroyed by fire. $35,000. Architect not selected.

Packing Plant—Roch, Winter & Walsh, 4th and Townsend Sts., San Francisco, Calif., awarded contract for a 2 story addition to packing plant on Townsend St. to Barrett & Hilp, 918 Harrison St., San Francisco. $42,000.

Packing Plant Additions—Phoenix Packing Co., Phoenix, Ariz., plans additions and installation of equipment to present sugar beet factory to be converted into packing plant at Glendale, Calif. Estimated cost $500,000.

Apple Evaporating Plant—Lakeville Evaporators, Ltd., Lakeville Station, N. S., plans the construction of an apple evaporating plant. Estimated cost $20,000.

Packing Plant—Growers Service Co., Fresno, Calif., will build a 1 story, 25 x 150 ft. packing plant. Work will be done by day labor.

Packing Plant—Mutual Orange Distributors Inc., Redlands, Calif., awarded contract for a 1 story, 90 x 200 ft. packing plant at Upland to International General Contractors, Roosevelt Bldg., Los Angeles. Estimated cost $45,000.

Packing Plant—San Fernando Valley Growers Assn., North Los Angeles, Calif., is having plans prepared for the construction of a 1 story, 120 x 140 ft. packing plant. Estimated cost $50,000. G. Chapman, 6262 Van Nuys Blvd., Van Nuys, is architect.

Packing Plant (Meat)—Bechtols Inc., Orrville, O., awarded contract for the construction of a 1 story, 80 x 120 ft. meat packing plant to Huszar Bros., Akron, O. Estimated cost $60,000.

Packing Plant (Meat)—Swift & Co., W. Robinson, 9th and Girard Sts., Philadelphia, Pa., awarded contract for the construction of a 3 story, 94 x 151 ft. addition to meat packing plant to Barclay White Co., 22 North 36th St., Philadelphia. Also plans a 2 story addition to meat storage plant on Sewall Ave., Asbury Park, N. J. $40,000.

Packing Plant (Meat) and Cold Storage Plant—Weil Packing Co., North Kentucky Ave., Evansville, Ind., awarded contract for the construction of a 2 story, 60 x 100 ft. meat packing plant including beef cooling rooms, smoked meat rooms, hog cutting rooms and cold storage rooms, to C. Kanzler & Son, 500 Furn. Bldg., Evansville. Estimated cost $50,000.